

- 6 DEC 1974
NATURAL HIST

ORDOVICIAN BRACHIOPODA FROM THE
SHELVE DISTRICT, SHROPSHIRE

BY

ALWYN WILLIAMS

The University of Birmingham

Pp. 1-163 ; 28 *Plates* ; 11 *Text-figures* ; 110 *Tables*

BULLETIN OF
THE BRITISH MUSEUM (NATURAL HISTORY)
GEOLOGY Supplement 11

LONDON: 1974

THE BULLETIN OF THE BRITISH MUSEUM (NATURAL HISTORY), instituted in 1949, is issued in five series corresponding to the Departments of the Museum, and an Historical series.

Parts will appear at irregular intervals as they become ready. Volumes will contain about three or four hundred pages, and will not necessarily be completed within one calendar year.

In 1965 a separate supplementary series of longer papers was instituted, numbered serially for each Department.

This paper is Supplement II of the Geological (Palaeontological) series. The abbreviated titles of periodicals cited follow those of the World List of Scientific Periodicals.

World List abbreviation :
Bull. Br. Mus. nat. Hist. (Geol.) Suppl.

© Trustees of the British Museum (Natural History), 1974

TRUSTEES OF
THE BRITISH MUSEUM (NATURAL HISTORY)

Issued 2 December 1974

Price £12.80

ORDOVICIAN BRACHIOPODA FROM THE SHELVE DISTRICT, SHROPSHIRE

By ALWYN WILLIAMS

CONTENTS

	<i>Page</i>
I. INTRODUCTION	8
II. FAUNAL DISTRIBUTION	9
III. FAUNAL ASSOCIATIONS	16
IV. SYSTEMATIC METHODS	23
V. SYSTEMATIC PALAEOLOGY	25
Class INARTICULATA Huxley	25
Order LINGULIDA Waagen	25
Superfamily Lingulacea Menke	25
Family Obolidae King	25
Subfamily Obolinae King	25
<i>Obolus</i> Eichwald	25
<i>Obolus subditivus</i> sp. nov.	25
<i>Obolus</i> sp.	26
<i>Schmidtites</i> Schuchert & Le Vene	26
<i>Schmidtites</i> ? <i>simplex</i> sp. nov.	26
<i>Schmidtites</i> ? <i>simplex subcircularis</i> sp. et subsp. nov.	27
Subfamily Lingulellinae Schuchert	28
<i>Lingulella</i> Salter	28
<i>Lingulella displosa</i> sp. nov.	28
<i>Lingulella displosa petila</i> sp. et subsp. nov.	29
<i>Palaeoglossa</i> Cockerell	31
<i>Palaeoglossa attenuata</i> Sowerby	32
<i>Palaeoglossa myttonensis</i> sp. nov.	33
Subfamily Glossellinae Cooper	35
<i>Pseudolingula</i> Mickwitz	35
<i>Pseudolingula spatula</i> sp. nov.	36
Family Elkaniidae Walcott & Schuchert	38
<i>Monobolina</i> Salter	38
<i>Monobolina plumbea</i> (Salter)	38
Family Paterulidae Cooper	40
<i>Paterula</i> Barrande	40
<i>Paterula</i> cf. <i>bohemica</i> Barrande	40
<i>Paterula</i> cf. <i>perfecta</i> Cooper	41
Order ACROTRETIDA Kuhn	42
Suborder ACROTRETIDINA Kuhn	42
Superfamily Acrotretacea Schuchert	42
Family Acrotretidae Schuchert	42
<i>Apsotreta</i> Palmer	42
<i>Apsotreta</i> sp.	42
<i>Conotreta</i> Walcott	43
<i>Conotreta stapeleyensis</i> sp. nov.	43
Superfamily Discinacea Gray	44

Family Trematidae Schuchert	44
<i>Schizocrania</i> Hall & Whitfield	44
<i>Schizocrania salopiensis</i> sp. nov.	44
Family Discinidae Gray	47
Subfamily Orbiculoideinae Schuchert & Le Vene	47
<i>Orbiculoidea</i> d'Orbigny	47
<i>Orbiculoidea</i> sp.	47
<i>Schizotreta</i> Kutorga	47
<i>Schizotreta transversa</i> sp. nov.	47
<i>Schizotreta</i> sp.	48
Suborder CRANIIDINA Waagen	48
Superfamily Craniacea Menke	48
Family Craniidae Menke	48
<i>Petrocrania</i> Raymond	48
<i>Petrocrania dubia</i> sp. nov.	48
Class ARTICULATA Huxley	49
Order ORTHIDA Schuchert & Cooper	49
Suborder ORTHIDINA Schuchert & Cooper	49
Superfamily Orthacea Woodward	49
Family Hesperonomiidae Ulrich & Cooper	49
<i>Hesperonomia</i> Ulrich & Cooper	49
<i>Hesperonomia</i> sp.	49
Family Orthidae Woodward	50
Subfamily Orthinae Woodward	50
<i>Orthis</i> Dalman	50
<i>Orthis</i> cf. <i>callactis</i> Dalman	50
<i>Orthis</i> sp.	51
<i>Lenorthis</i> Andreeva	52
<i>Lenorthis</i> cf. <i>proava</i> (Salter)	52
<i>Orthambonites</i> Pander	53
<i>Orthambonites exopunctata</i> sp. nov.	53
Subfamily Productorthinae Schuchert & Cooper	57
<i>Nicolella</i> Reed	57
<i>Nicolella</i> cf. <i>actoniae</i> (J. de C. Sowerby)	57
Subfamily Whittardiinae nov.	60
<i>Whittardia</i> gen. nov.	62
<i>Whittardia paradoxica</i> gen. et sp. nov.	62
Family Dolerorthidae Öpik	63
Subfamily Dolerorthinae Öpik	63
<i>Dolerorthis</i> Schuchert & Cooper	63
<i>Dolerorthis</i> cf. <i>tenuicostata</i> Williams	63
Subfamily Glyptorthinae Schuchert & Cooper	64
<i>Glyptorthis</i> Foerste	64
<i>Glyptorthis viriosa</i> sp. nov.	64
Family Alimbellidae Andreeva	68
<i>Astraborthis</i> gen. nov.	68
<i>Astraborthis uniplicata</i> gen. et sp. nov.	70
Family Finkelnburgiidae Schuchert & Cooper	71
<i>Diparelasma</i> Ulrich & Cooper	71
<i>Diparelasma</i> sp.	71
Family Plectorthidae Schuchert & Le Vene	71
Subfamily Plectorthinae Schuchert & Le Vene	71
<i>Plectorthis</i> Hall & Clarke	71
<i>Plectorthis whitteryensis</i> sp. nov.	71

<i>Plectothis</i> sp.	73
<i>Desmorthis</i> Ulrich & Cooper	73
<i>Desmorthis</i> ? sp. nov.	73
<i>Gelidorthis</i> Havlíček	74
<i>Gelidorthis</i> cf. <i>partita</i> (Barrande)	74
<i>Tazzarinia</i> Havlíček	75
<i>Tazzarinia elongata</i> sp. nov.	75
Subfamily Platystrophiinae Schuchert & Le Vene	76
<i>Platystrophia</i> King	76
<i>Platystrophia caelata</i> sp. nov.	76
<i>Platystrophia</i> cf. <i>major</i> Williams	78
<i>Mcewanella</i> Foerste	78
<i>Mcewanella</i> sp.	78
<i>Salacorthis</i> gen. nov.	79
<i>Salacorthis costellata</i> gen. et sp. nov.	80
Family Skenidiidae Kozłowski	82
<i>Skenidioides</i> Schuchert & Cooper	82
<i>Skenidioides</i> cf. <i>costatus</i> Cooper	82
<i>Protoskenidioides</i> gen. nov.	83
<i>Protoskenidioides revelata</i> gen. et sp. nov.	85
Superfamily Enteletacea Waagen	87
Family Schizophoriidae Schuchert & Le Vene	87
Subfamily Draboviinae Havlíček	87
<i>Drabovia</i> Havlíček	87
<i>Drabovia</i> cf. <i>fasciostata</i> Havlíček	87
<i>Nocturniella</i> Havlíček	88
<i>Nocturniella</i> sp.	88
Family Dalmanellidae Schuchert	89
<i>Dalmanella</i> Hall & Clarke	89
<i>Dalmanella parva</i> Williams	89
<i>Dalmanella salopiensis</i> sp. nov.	90
<i>Dalmanella salopiensis gregaria</i> sp. et subsp. nov.	91
<i>Dalmanella salopiensis transversa</i> sp. et subsp. nov.	92
<i>Dalmanella elementaria</i> sp. nov.	97
<i>Onniella</i> Bancroft	98
<i>Onniella ostentata</i> Williams <i>lepida</i> subsp. nov.	98
Family Harknessellidae Bancroft	102
<i>Harknessella</i> Reed	102
<i>Harknessella</i> cf. <i>subplicata</i> Bancroft	102
<i>Hordeleyella</i> Bancroft	102
<i>Hordeleyella</i> cf. <i>plicata</i> Bancroft	102
<i>Hordeleyella</i> sp.	104
<i>Reuschella</i> Bancroft	104
<i>Reuschella hordeleyensis</i> Bancroft <i>carinata</i> subsp. nov.	104
Family Heterorthidae Schuchert & Cooper	106
<i>Heterorthis</i> Hall & Clarke	106
<i>Heterorthis</i> sp.	106
<i>Tissintia</i> Havlíček	107
<i>Tissintia prototypa</i> (Williams)	108
<i>Tissintia immatura</i> (Williams)	109
Family Linoporellidae Schuchert & Cooper	114
<i>Salopia</i> Williams	114
<i>Salopia</i> cf. <i>salteri</i> (Davidson)	114
<i>Salopia</i> sp.	114

Suborder CLITAMBONITIDINA Öpik	115
Superfamily Gonambonitacea Schuchert & Cooper	115
Family Gonambonitidae Schuchert & Cooper	115
Subfamily Anomalorthinae Ulrich & Cooper	115
<i>Oslogonites</i> Öpik	115
<i>Oslogonites</i> ? sp.	115
Family Kullervoidae Öpik	115
<i>Kullervo</i> Öpik	115
<i>Kullervo</i> sp.	115
Suborder TRIPLESIIDINA Moore	116
Superfamily Triplesiaea Schuchert	116
Family Triplesiidae Schuchert.	116
<i>Triplesia</i> Hall	116
<i>Triplesia</i> sp.	116
<i>Bicuspina</i> Havlíček	117
<i>Bicuspina subquadrata</i> sp. nov.	117
<i>Bicuspina modesta</i> sp. nov..	118
<i>Caeroplecia</i> gen. nov.	121
<i>Caeroplecia plicata</i> gen. et sp. nov.	122
<i>Oxoplecia</i> Wilson	124
<i>Oxoplecia</i> cf. <i>nantensis</i> MacGregor	125
Order STROPHOMENIDA Öpik	126
Suborder STROPHOMENIDINA Öpik	126
Superfamily Plectambonitacea Jones	126
Family Leptestiidae Öpik	126
Subfamily Leptestiinae Öpik	126
<i>Palaeostrophomena</i> Høltedahl	126
<i>Palaeostrophomena</i> sp.	126
Family Eocramatiidae nov.	127
<i>Eocramatia</i> gen. nov.	128
<i>Eocramatia dissimulata</i> gen. et sp. nov.	129
Family Sowerbyellidae Öpik	130
Subfamily Sowerbyellinae Öpik	130
<i>Sowerbyella</i> Jones	130
<i>Sowerbyella antiqua</i> Jones	130
<i>Sowerbyella</i> cf. <i>antiqua</i> Jones	131
<i>Sowerbyella multiseptata</i> sp. nov.	132
<i>Sowerbyella</i> cf. <i>sericea permixta</i> Williams	133
<i>Sowerbyella</i> cf. <i>sericea</i> (J. de C. Sowerby)	134
Subfamily Aegiromeninae Havlíček	139
<i>Sericoidea</i> Lindström	139
<i>Sericoidea</i> cf. <i>abdita</i> Williams	139
Superfamily Strophomenacea King	140
Family Strophomenidae King	140
Subfamily Furcitellinae Williams	140
<i>Furcitella</i> Cooper	140
<i>Furcitella</i> sp.	140
<i>Murinella</i> Cooper	141
<i>Murinella</i> sp.	141
Subfamily Rafinesquininae Schuchert	141
<i>Rafinesquina</i> Hall & Clarke	141
<i>Rafinesquina delicata</i> sp. nov.	141
<i>Rafinesquina</i> sp.	143
<i>Kjaerina (Hedstroemina)</i> Bancroft	145

<i>Kjaerina (Hedstroemina)</i> sp.	145
Subfamily Glyptomeninae Williams	145
<i>Bystromena</i> gen. nov.	145
<i>Bystromena perplexa</i> gen. et sp. nov.	146
Family Leptaenidae Hall & Clarke	148
<i>Leptaena</i> Dalman	148
<i>Leptaena</i> cf. <i>ventricosa</i> Williams	148
<i>Kiaeromena</i> Spjeldnaes	149
<i>Kiaeromena</i> cf. <i>kjerulfi</i> (Holtedahl)	149
Order PENTAMERIDA Schuchert & Cooper	150
Suborder SYNTROPHIIDINA Ulrich & Cooper	150
Superfamily Porambonitacea Davidson	150
Family Syntrophiidae Schuchert	150
Subfamily Xenelasmatinae Ulrich & Cooper	150
<i>Euorthisina</i> Havlíček	150
<i>Euorthisina</i> cf. <i>moesta minor</i> Havlíček	150
Family Parastrophinidae Ulrich & Cooper	151
<i>Parastrophinella</i> Schuchert & Cooper	151
<i>Parastrophinella musculosa</i> sp. nov.	151
<i>Parastrophinella</i> sp.	152
Order RHYNCHONELLIDA Kuhn	153
Superfamily Rhynchonellacea Gray	153
Family Trigonirhynchiidae McLaren	153
<i>Rostricellula</i> Ulrich & Cooper	153
<i>Rostricellula sparsa</i> Williams	153
Order SPIRIFERIDA Waagen	154
Suborder ATRYPIDINA Moore	154
Superfamily Atrypacea Gill	154
Family Atrypidae Gill	154
Subfamily Zygospirinae Waagen	154
<i>Zygospira</i> Hall	154
<i>Zygospira</i> sp.	154
VI. ACKNOWLEDGMENTS	154
VII. REFERENCES	155
VIII. INDEX	158

SYNOPSIS

A study of fossil Brachiopoda collected mainly as moulds from the Ordovician successions of the Shelve area, reveals the presence of 83 species and subspecies (35 of them new) belonging to 63 genera, of which *Astrorthis*, *Protoskenidioides*, *Salacorthis* and *Whittardia* are new orthaceans, *Caeroplecia* a new triplesiacean, *Eocramatia* a new plectambonitacean and *Bystromena* a new strophomenacean. *Whittardia* is placed in a new subfamily Whittardiinae and *Eocramatia* in a new family Eocramatiidae.

The number of taxa identified in assemblages recovered from any one formation is small, and only exceeds 20 in the Spy Wood Grit and Whittery Shales. This relative poverty of the faunas is at least partly related to rock type, with a dominantly inarticulate association comprising only a few genera prevalent in shales, and a richer, mainly articulate association more typical of the siltstones and sandstones. Both associations evolved by significant replacements of genera as well as species from one horizon to another, so that no combination of taxa can be described as consistently characteristic of either.

The faunas are also restricted in geographical distribution. They show affinities with assemblages from Wales and E. Shropshire and confirm the currently adopted correlation of the

Shelve rocks with the standard Anglo-Welsh succession. However, taxa which also occur in Bohemia and Morocco generally appear earlier in the Shropshire successions and do not assist in precise correlation with either region.

I. INTRODUCTION

THIS paper is primarily a systematic study of Ordovician brachiopods collected by the late Professor W. F. Whittard with the assistance of Mr T. R. Fry during an investigation of the rocks of W. Shropshire that lasted for more than 30 years. Over that period, he amassed an unprecedented number of brachiopods, trilobites, graptolites and miscellaneous invertebrates. The brachiopod collection alone, which is mainly composed of moulds, includes over 3000 specimens well enough preserved to provide statistical information and about half as many identifiable, albeit incomplete, impressions. In fact the collection is not only a tribute to the patience, acute observation and indefatigable energies of Professor Whittard and his assistants, but also a measure of his brilliance as a systematist. Thus when the specimens, all clearly numbered, arrived in the Queen's University of Belfast in 1962, they were so unambiguously documented in relation to his field maps that after his untimely death in 1966 only a few score could not be precisely assigned to a locality, although the stratigraphic horizon of each was accurately known. Almost invariably, therefore, it has been possible to supplement Whittard's original directions and measurements (given in yards) for the identification of fossiliferous localities by citing National Grid references, which indicate position within the kilometre squares of the Ordnance Survey maps. Indeed only two unlocated specimens have been described and figured in the present systematic account, and although this has been done because the specimens are unique, they have not been made the types of any new taxa.

The systematic study itself was begun in 1965. But for various reasons it was discontinued until recently, when it became evident that such a protracted delay in publication of a description of the collection was gravely detrimental to our understanding of British Ordovician palaeogeography and hence of subduction zones of ancient continental plates. In a regional context, the work may be regarded as a supplement to Whittard's own scholarly monographs on the Ordovician trilobites of W. Shropshire. Together with Dr W. T. Dean's forthcoming publication of a geological map of the Shelve area based on Whittard's field studies, and Dr I. Strachan's identification of the graptolitic assemblages, they give a much more comprehensive and detailed assessment of the Ordovician stratigraphy and palaeontology of the Shelve area than ever before.

The collection was given to the writer by Professor Whittard in expectation that it would ultimately find its way to one of the national repositories where it could be adequately housed and curated. Consequently, all specimens, except for a few lost in the preparation of rock sections, have been donated to the Department of Palaeontology of the British Museum (Natural History): their registered numbers, lying in the ranges BB 35305-35600 and BB 37107-37162, are given.

II. FAUNAL DISTRIBUTION

The brachiopods collected from the Ordovician rocks of the Shelve district have been assigned to the 85 identifiable taxa described in the systematic section, with 19 species classified as Inarticulata, 41 as Orthida, 5 as Triplesiida, 15 as Strophomenida, 3 as Pentamerida and 1 each as Rhynchonellida and Spiriferida. The taxa are unevenly distributed in the succession with :

19 species recorded from	36 localities of	Mytton Flags (A),					
7	”	”	”	18	”	”	Hope Shales (B),
8	”	”	”	12	”	”	Stapeley Volcanic Group (C),
5	”	”	”	16	”	”	Weston Beds (D),
8	”	”	”	23	”	”	Betton Beds (E),
17	”	”	”	41	”	”	Meadowtown Beds (F),
16	”	”	”	52	”	”	Rorrington Beds (G),
21	”	”	”	8	”	”	Spy Wood Grit (H),
14	”	”	”	8	”	”	Aldress Shales (I),
15	”	”	”	4	”	”	Hagley Shales (J),
and	23	”	”	4	”	”	Whittery Shales (K).

In the following comprehensive list of stratigraphic distribution, the lower case letters 'r' (rare), 'fc' (fairly common), 'c' (common), and 'vc' (very common) respectively represent the retrieval of one or more specimens of a listed species in 0-25%, 26-50%, 51-75%, 76-100% of all localities for any one formation, while the capital letters 'A', 'B', 'C' etc. at the head of the list are keys to formations in the order given above. The list is :

	A	B	C	D	E	F	G	H	I	J	K
<i>Apsotreta</i> sp.	r	-	-	-	-	-	-	-	-	-	-
<i>Astrorthis uniplicata</i> gen. et sp. nov.	r	-	-	-	-	-	-	-	-	-	-
<i>Bicuspina modesta</i> sp. nov.	-	-	-	-	-	-	r	c	-	-	-
<i>Bicuspina subquadrata</i> sp. nov.	-	-	-	-	-	-	-	-	r	fc	vc
<i>Bystromena perplexa</i> gen. et sp. nov.	-	-	-	-	-	-	-	vc	-	-	-
<i>Caeroplecia plicata</i> gen. et sp. nov.	-	-	-	-	-	-	-	-	-	r	vc
<i>Conotreta stapeleyensis</i> sp. nov.	-	r	r	-	-	-	-	-	-	-	-
<i>Dalmanella elementaria</i> sp. nov.	r	-	-	-	-	-	-	-	-	-	-
<i>Dalmanella salopiensis</i> sp. nov.	-	-	-	-	r	c	r	-	-	-	-
<i>Dalmanella salopiensis gregaria</i> sp. et subsp. nov.	-	-	-	-	-	-	-	vc	-	-	-
<i>Dalmanella salopiensis transversa</i> sp. et subsp. nov.	-	-	-	-	-	-	-	-	fc	-	-
<i>Desmorthis</i> ? sp. nov.	r	-	r	-	-	-	-	-	-	-	-
<i>Diplarelasma</i> sp.	r	-	-	-	-	-	-	-	-	-	-
<i>Dolerorthis</i> cf. <i>tenuicostata</i> Williams	-	-	-	-	-	-	-	-	-	-	r
<i>Drabovia</i> cf. <i>fascicostata</i> Havlíček	-	-	-	-	-	-	-	fc	-	-	-
<i>Eocramatia dissimulata</i> gen. et sp. nov.	-	r	-	-	-	-	-	-	-	-	-
<i>Euorthisina</i> cf. <i>moesta minor</i> Havlíček	r	-	-	-	-	-	-	-	-	-	-
<i>Furcitella</i> sp.	-	-	-	-	-	-	-	-	-	-	r
<i>Gelidorthis</i> cf. <i>partita</i> (Barrande)	-	-	-	-	-	-	r	-	-	-	-

	A	B	C	D	E	F	G	H	I	J	K
<i>Glyptorthis viriosa</i> sp. nov.	-	-	-	-	-	r	r	vc	-	-	r
<i>Harknessella</i> cf. <i>subplicata</i> Bancroft	-	-	-	-	-	-	-	r	-	-	-
<i>Hesperonomia</i> sp.	r	-	-	-	-	-	-	-	-	-	-
<i>Heterorthis</i> sp.	-	-	-	-	-	-	r	fc	r	-	-
<i>Holderleyella</i> cf. <i>plicata</i> Bancroft	-	-	-	-	-	-	-	fc	r	-	-
<i>Holderleyella</i> sp.	-	-	-	-	-	r	-	-	-	-	-
<i>Kiaeromena</i> cf. <i>kjerulfi</i> (Holtedahl)	-	-	-	-	-	-	-	-	-	r	r
<i>Kjaerina</i> (<i>Hedstroemina</i>) sp.	-	-	-	-	-	-	-	fc	-	-	-
<i>Kullervo</i> sp.	-	-	-	-	-	r	-	-	-	-	-
<i>Lenorthis</i> cf. <i>proava</i> (Salter)	fc	-	-	-	-	-	-	-	-	-	-
<i>Leptaena</i> cf. <i>ventricosa</i> Williams	-	-	-	-	-	-	-	-	-	fc	c
<i>Lingulella displosa</i> sp. nov.	-	-	-	-	r	r	fc	-	r	-	-
<i>Lingulella displosa petila</i> sp. et subsp. nov.	-	-	fc	-	-	-	-	-	-	-	-
<i>Mcewanella</i> sp.	-	-	-	-	-	-	-	-	-	-	r
<i>Monobolina plumbea</i> (Salter)	c	-	-	-	-	-	-	-	-	-	-
<i>Murinella</i> sp.	-	-	-	-	-	r	-	-	-	-	-
<i>Nicolella</i> cf. <i>actoniae</i> (Sowerby)	-	-	-	-	-	-	-	-	-	r	vc
<i>Nocturniella</i> sp.	r	-	-	-	-	-	-	-	-	-	-
<i>Obolus subditivus</i> sp. nov.	-	c	-	-	-	-	-	-	-	-	-
<i>Obolus</i> sp.	r	-	-	-	-	-	-	-	-	-	-
<i>Onniella ostentata lepida</i> subsp. nov.	-	-	-	-	-	-	-	-	fc	vc	vc
<i>Onniella</i> sp.	-	-	-	-	-	-	-	r	-	-	-
<i>Orbiculoidea</i> sp.	-	-	r	-	-	-	-	-	-	-	-
<i>Orthambonites exopunctata</i> sp. nov.	-	-	-	-	-	-	-	-	-	fc	vc
<i>Orthambonites</i> sp.	-	-	-	-	-	-	-	-	r	-	-
<i>Orthis</i> cf. <i>callacis</i> Dalman	r	-	-	-	-	-	-	-	-	-	-
<i>Orthis</i> sp.	-	-	r	-	-	-	-	-	-	-	-
<i>Oslogonites</i> ? sp.	r	-	-	-	-	-	-	-	-	-	-
<i>Oxoplecia</i> cf. <i>nantensis</i> MacGregor	-	-	-	-	-	r	-	-	-	-	-
<i>Palaeoglossa attenuata</i> (Sowerby)	-	-	-	fc	c	vc	c	c	r	-	r
<i>Palaeoglossa myttonensis</i> sp. nov.	c	-	-	-	-	-	-	-	-	-	-
<i>Palaeostrophomena</i> sp.	-	-	-	-	-	-	-	-	-	-	c
<i>Parastrophinella musculosa</i> sp. nov.	-	-	-	-	-	-	-	fc	-	-	-
<i>Parastrophinella</i> sp.	-	-	-	-	-	-	-	-	-	r	-
<i>Paterula</i> cf. <i>bohemica</i> Barrande	r	fc	-	-	r	-	-	-	-	-	-
<i>Paterula</i> cf. <i>perfecta</i> Cooper	-	-	-	-	-	r	r	fc	c	-	-
<i>Petrocrania dubia</i> sp. nov.	-	-	-	-	-	-	-	-	r	r	fc
<i>Platystrophia caelata</i> sp. nov.	-	-	-	-	-	-	-	-	-	fc	vc
<i>Platystrophia</i> cf. <i>major</i> Williams	-	-	-	-	-	-	-	fc	-	-	-
<i>Plectorthis whitteryensis</i> sp. nov.	-	-	-	-	-	-	-	-	-	r	r
<i>Plectorthis</i> sp.	-	-	-	-	-	-	-	-	r	-	-
<i>Protoskenidioides revelatus</i> gen. et sp. nov.	r	-	-	-	-	-	-	-	-	-	-
<i>Pseudolingula spatula</i> sp. nov.	r	r	-	c	-	fc	r	-	-	-	-
<i>Rafinesquina delicata</i> sp. nov.	-	-	-	-	r	fc	-	-	-	-	-
<i>Rafinesquina</i> sp.	-	-	-	-	-	-	r	-	r	-	r
<i>Reuschella holderleyensis carinata</i> subsp. nov.	-	-	-	-	-	-	-	-	-	c	vc
<i>Rostricellula sparsa</i> Williams	-	-	-	-	-	-	-	r	-	-	-
<i>Salacorthis costellata</i> gen. et sp. nov.	-	-	-	-	-	-	-	fc	-	-	-
<i>Salopia</i> cf. <i>salteri</i> (Davidson)	-	-	-	-	-	-	-	-	r	-	-
<i>Salopia</i> sp.	-	-	-	-	-	-	-	-	-	r	fc
<i>Schizocrania salopiensis</i> sp. nov.	-	fc	r	fc	fc	r	c	c	-	-	-
<i>Schizotreta transversa</i> sp. nov.	-	-	-	-	-	r	r	-	-	-	-
<i>Schizotreta</i> sp.	r	r	r	r	-	-	-	-	-	-	-

	A	B	C	D	E	F	G	H	I	J	K
<i>Schmidites ? simplex</i> sp. nov.	-	-	-	-	r	r	fc	-	fc	-	-
<i>Schmidites ? simplex subcircularis</i> sp. et subsp. nov.	r	-	fc	-	-	-	-	-	-	-	-
<i>Sericoidea</i> cf. <i>abdita</i> Williams	-	-	-	-	-	-	-	-	-	r	-
<i>Skenidioides</i> cf. <i>costatus</i> Cooper	-	-	-	-	-	-	r	fc	-	-	c
<i>Sowerbyella</i> cf. <i>antiqua</i> Jones	-	-	-	-	-	r	-	-	-	-	-
<i>Sowerbyella multiseptata</i> sp. nov.	-	-	-	-	-	-	-	c	-	-	-
<i>Sowerbyella</i> cf. <i>sericea permixta</i> Williams	-	-	-	-	-	-	-	-	fc	-	-
<i>Sowerbyella</i> cf. <i>sericea</i> (Sowerby)	-	-	-	-	-	-	-	-	-	fc	vc
<i>Sowerbyella</i> sp.	-	-	-	-	-	-	r	-	-	-	-
<i>Tazzarinia elongata</i> sp. nov.	-	-	-	-	-	r	-	-	-	-	-
<i>Tissintia immatura</i> (Williams)	-	-	-	-	-	fc	-	-	-	-	-
<i>Tissintia prototypa</i> (Williams)	-	-	-	c	fc	-	-	-	-	-	-
<i>Triplesia</i> sp.	-	-	-	-	-	-	-	-	-	-	r
<i>Whittardia paradoxica</i> gen. et sp. nov.	-	-	-	-	-	-	-	-	-	-	c
<i>Zygospira</i> sp.	-	-	-	-	-	-	-	r	-	-	-

The list does not include the few poorly preserved inarticulate brachiopods recovered from the Stiperstone Quartzite which were: a discinid, an obolid and *Pseudolingula* sp.

The large number of identifications reflect the assiduity of the collectors and the great range of geologic time represented by the strata from which specimens have been recovered, rather than any intrinsic richness of faunas. Compared with contemporaneous faunas from Scotland or the Baltic, for example, the Shelve assemblages are restricted in content. This relative paucity may be illustrated (Text-fig. 1) by estimating the number of species recorded per 300 m of rock for each formation, using thicknesses given by Watts (1925) and Whittard (1952). The greatest diversity of about 76 species per 300 m for the Whittery Shales is only one-third that calculated for the penecontemporaneous Balclatchie Mudstones (Williams 1962 : 27). This contrast is further emphasized by the negligible taxonomic communality, even at generic level, between the Shelve assemblages and coeval Scottish or Baltic ones, and appears to be related to profound environmental differences ranking with provincial distinctions (Williams 1973 : 246) in Recent seas. Accordingly only assemblages found in Wales, E. Shropshire and, to a lesser extent, N. Africa and Bohemia are like those of the Shelve area; and even these show discrepancies in stratigraphic distributions and frequencies of occurrence probably linked to the benthic habits of brachiopods.

The brachiopods occurring in the Mytton Flags have an Arenigian aspect even in relation to assemblages characteristic of more remote regions. *Desmorthis*, *Diparelasma* and *Hesperonomia* are reminiscent of American successions (Ulrich & Cooper 1938 : 27-28); *Orthis callactis* (Rubel 1961 : 142) and *Oslogonites* (Öpik 1939 : 118) of the Baltic region; and *Euorthisina* and *Nocturniella* (Havlíček & Vaněk 1966 : 50) of Czechoslovakia, although the species with which the Shelve *Euorthisina* has been compared occurs in the Llanvirnian Šárka Formation of Bohemia and the Llanvirnian Tachilla Shales of Morocco (Havlíček 1971 : 75). With respect to more precise correlation with other Anglo-Welsh successions, only *Lenorthis proava* has

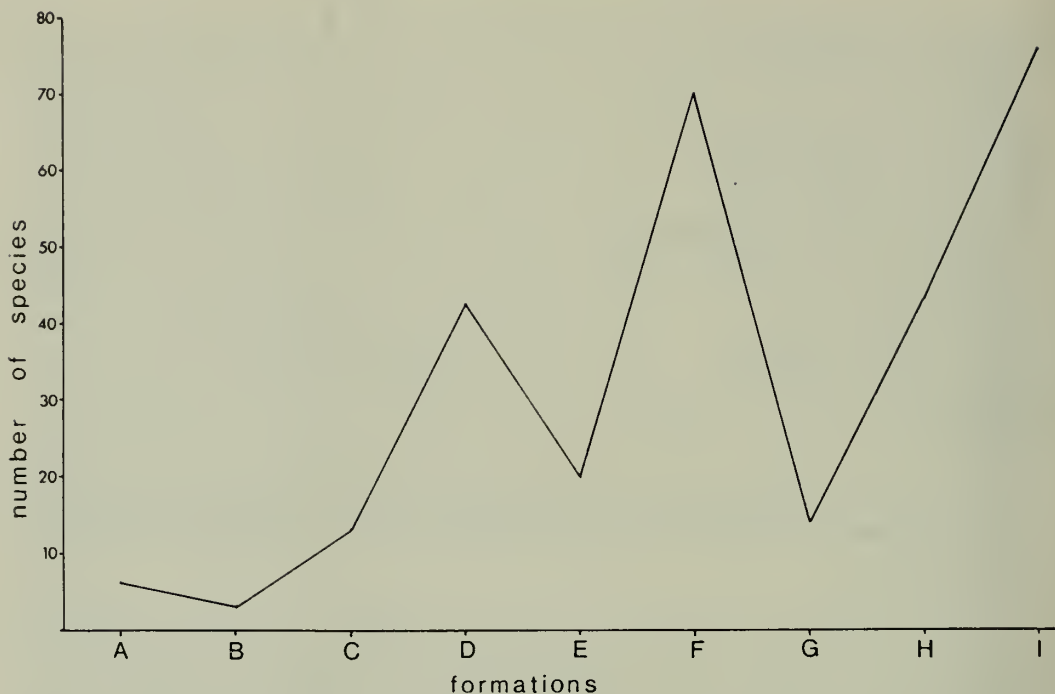


FIG. 1. Graph showing the estimated number of species recorded per 300 m of: Mytton Flags (A); Hope Shales, Stapeley Shales and Weston Beds (B); Betton Beds (C); Meadowtown Beds (D); Rorrington Beds (E); Spy Wood Grit (F); Aldress Shales (G); Hagley Shales (H); and Whittery Shales (I).

proved useful so far. In its type area of Anglesey, this species occurs in Arenigian rocks (Bates 1968 : 147) and is associated with *Hesperonomiella* which is probably closely related to the *Hesperonomia* of the Shelve area. *L. proava* also occurs in the contemporaneous Henllan Ashes of the Arenig district and authenticated reports of its widespread occurrence are in sharp contrast to the lack of information on the distribution of the other common Shelve brachiopod, *Monobolina plumbea*, or of inarticulates generally in the Welsh successions. Clearly these early Ordovician assemblages are in urgent need of investigation.

Despite taxonomic neglect of the older Llanvirn brachiopod faunas, a fairly close likeness between the Llanvirn-Llandeilo assemblages of W. Shropshire and Carmarthenshire can be discerned. This is especially true when one takes into account the longer ranging constituents of the fauna like *Lingulella*, *Palaeoglossa*, *Paterula*, *Pseudolingula* and *Schizocrania* which occur in both areas. However these species, although indicative of similar biofacies, are not very useful for correlation which is dependent on comparatively few articulate species.

Tissintia prototypa is confined to the Weston and Betton formations of the Shelve area, both of which should now be assigned to the Upper Llanvirnian *Didymograptus murchisoni* zone according to I. Strachan (in Whittard 1966 : 297). The species is

also narrowly ranging in the Llandeilo area where it occurs in ashy shales of the *Didymograptus bifidus* zone and in the succeeding basal beds of the Ffairfach Grit at Ffairfach. *Tissintia immatura*, on the other hand, is found throughout the Llandeilo Flags (Williams 1953 : 190-194), while its so-called 'variety' *T. immatura plana* is also recorded from conglomeratic sandstones (Williams 1953 : 185) recognized as the top member of the Ffairfach Group—specimens identified as this sub-species, from the basal Ffairfach Grit at Garn-wen, actually belong to *T. prototypa* (Williams 1953 : 184). In the Shelve area, *T. immatura* is restricted to the Meadowtown Beds; presumably its absence from the Rorrington Beds, which are now correlated with the Middle and Upper Llandeilo Flags (Bassett in Williams *et al.* 1972 : 33), may be attributed to adverse environmental conditions. The distribution of *Tissintia* in Shropshire and Carmarthenshire therefore suggests that the Betton Beds and at least part of the Weston Beds should be correlated with the Ffairfach Group, and the Meadowtown Beds with the Lower Llandeilo and, possibly, the top conglomeratic member of the Ffairfach Group.

Other brachiopods tend to confirm this correlation. *Sowerbyella antiqua* is known from the Betton Beds and from the lower part of the Meadowtown Beds, and although it is common at certain horizons in the Ffairfach Group and Lower Llandeilo, it is unknown from the Middle and Upper Llandeilo Flags. The small *Dalmanella* found in both areas constitute two morphologically distinctive stocks. But the differences between them may have been phenotypic, and it is noteworthy that they first appeared in the Betton and Ffairfach successions simultaneously with *Sowerbyella*. *Oxoplecia nantensis*, which was first described by MacGregor (1961 : 196) from the Upper Llandeilo rocks of the Berwyn Dome, is widely distributed in the Llandeilo strata of S.W. Wales and a related form has been recovered from the Ffairfach Group. *Horderleyella* on the other hand, which is well represented in Welsh successions, rarely occurs, and then only as an indeterminate species in the Meadowtown Beds. Moreover the Shropshire strophomenid has surprisingly proved to be a new species of *Rafinesquina* unrelated to its well-known contemporary *Macrocoelia llanveiloensis*. This unexpected discovery suggests that the Welsh Llanvirn-Llandeilo strophomenids require revision because those previously identified as the species '*llanveiloensis*' may prove to belong to two different genera.

The graptolite-bearing Rorrington Beds and the trilobite-rich Middle and Upper Llandeilo Flags have different biofacies. Each has yielded a subordinate but distinctive brachiopod assemblage, with a predominance of inarticulates in the Rorrington Beds and of *Tissintia* and *Dalmanella* in the Llandeilo Flags. Indeed articulate brachiopods found in the Rorrington Beds are usually immature specimens indeterminate at infrageneric level, although *Bicuspina*, *Heterorthis* and *Skenidioides*, as precursory elements of the Spy Wood fauna, deserve attention. The first two, together with *Gelidorthis* cf. *partita*, are reminiscent of Middle Caradocian assemblages of Morocco (Havlíček 1971) and Czechoslovakia (Havlíček and Vaněk 1966 : 54-55). This earlier appearance in the Anglo-Welsh successions than in Bohemian or African strata of articulate brachiopods seems to have been part of a recurrent pattern, possibly representing the effects of diachronic migration. Thus *Tissintia* is not known in Morocco until mid-Llandeilo times; and *Tazzarinia*, which has been collected from

Meadowtown Beds, first occurs in Morocco in the Lower Caradocian part of the Ktaoua Formation.

The greater diversity of post-Rorrington brachiopod faunas affords an opportunity to apply Bancroft's Caradocian stages (1945) to the younger Shelve formations and thereby effect a correlation with the classic sections of E. Shropshire.

The Spy Wood Grit, with *Harknessella* cf. *subplicata*, *Horderleyella* cf. *plicata*, *Salopia* cf. *salteri* and young specimens of *Heterorthis*, may be correlated with the Coston Beds (Dean 1958: 218). The latter also contain undescribed *Bicuspina*, small *Dalmanella*, *Glyptorthis*, and *Sowerbyella*, which may prove to be conspecific with those found in the Shelve area. Further afield in Wales, the additional presence of *Platystrophia* cf. *major*, *Skenidioides* cf. *costatus* and *Salacorthis* suggests contemporaneity with the early Caradocian faunas of the Arenig district and Anglesey (Whittington and Williams 1955; Bates 1968), and W. Carmarthenshire and Pembrokeshire (R. Addison pers. comm.).

The Aldress Shales are less decisively dateable because the pre-Soudleyan brachiopods of E. Shropshire are largely undescribed. But the occurrence of *Sowerbyella* cf. *sericea permixta* is an indirect link through its first appearance within the Nant Hir Mudstones of the Bala district (Bassett, Whittington & Williams 1966: 263-264) and suggests that the formation is at least Harnagian in age.

The relative richness of the Hagley and Whittery faunas is in keeping with their identification as part of an evolving *Nicolella* association (Williams 1973: 242). This association is known to have occupied the Anglo-Welsh Basin sporadically throughout Caradocian times, being prevalent in the Costonian Derfel Limestone and Longvillian Gelli-grin Calcareous Ashes of the Bala district (Williams 1963: 341) and the Upper Longvillian to Actonian formations inclusive of E. Shropshire (Dean 1958: 221-224). Consequently the Shelve assemblages appear to be partly an anachronistic blend of earlier and later forms. Thus *Caeroplecia*, *Palaeostrophomena*, *Platystrophia* and *Salopia* are also known from the Derfel Limestone although they are represented by different species, but another distinctive member of the association, *Dolerorthis tenuicostata*, is not. In contrast to these similarities, *Nicolella actoniae* (or a subspecies), *Onniella ostentata* and *Sowerbyella sericea* are known from Longvillian successions in N. Wales and/or E. Shropshire. Finally *Bicuspina* and *Reuschella* are unknown from pre-Soudleyan strata and *Kiaeromena* cf. *kjerulfi* and *Leptaena ventricosa* first appear in the Soudleyan Allt Ddu Mudstones. Indeed, bearing in mind the extraordinary range of *N. actoniae* including its occurrence in the Cautleyan Portrane Limestone (Wright 1964: 165), and the complex relationship among the Sowerbyellas of N. Wales which are mainly closely related to *S. sericea*, the Hagley and Whittery brachiopod assemblages are most likely to be Soudleyan in age.

Like the older brachiopod assemblages, the Caradocian faunas of Shelve contain very few taxa of use in establishing even a tentative correlation with the biostratigraphic successions of other provinces. Only the Caradocian rocks of Bohemia and Morocco have yielded faunas with an overall similarity, although the majority of common elements again first appear in demonstrably younger rocks than in Shropshire in Bohemia (Havlíček and Vaněk 1966: 53-57). *Heterorthis*, *Horderleyella*,

Onniella and *Reuschella*, for example, first occur in the Zahorány Formation, *Dalmanella* in the Letná Formation and *Bicuspina* and *Drabovia* in the Liběň Formation, which have been dated as Soudleyan, Harnagian and Costonian respectively (Williams in Williams *et al.* 1972 : fig. 2). Moreover, even so characteristic a

Standard Succession		Shelve Succession	
CARADOC	Soudleyan	Whittery Shales	
		Whittery Volcanic Gp.	
		Hagley Shales	
		Hagley Volcanic Gp.	
	— ? —	Harnagian	Aldress Shales
		Costonian	Spy Wood Grit
LLANDEILO	Upper Middle	Rorrington Beds	
	Lower	Meadowtown Beds	
LLANVIRN	Upper	Betton Beds	
		Weston Beds	
	Lower	Stapeley Shales	
		Stapeley Volcanic Gp.	
		Hope Shales	
ARENIG		Mytton Flags (s.l.)	
		Stiperstones Quartzite	

FIG. 2. Classification of the Ordovician rocks of the Shelve area according to the brachiopod faunas.

Bohemian stock as *Drabovia* is represented in the Costonian Spy Wood Grit by *D. fascicostata*, which is known in Czechoslovakia only from the allegedly younger Letná Formation.

In summary then, it appears that although the W. Shropshire assemblages of Ordovician brachiopod species are strongly endemic and not reliable indices for correlation outside the Anglo-Welsh Basin, they do confirm the time-stratigraphic classification of the Shelve succession proposed by Dean (in Whittard 1967 : 317) except for the equation of the Rorrington Beds with the Middle and Upper Llan-deilian rather than the basal Caradocian (Text-fig. 2).

III. FAUNAL ASSOCIATIONS

The calculation of density distributions of species solely according to the frequency of their presence in localities for any given formation, as in the preceding section, is effective enough for determining the degree to which a taxon is diagnostic of a particular stratigraphic horizon. Such estimates, however, do not give any indication of the relative commonness of occurrence of species recovered from any single locality: of how, for example, *Palaeoglossa myttonensis* and *Protoskenidioides revelata* are recorded from 13 and 3 localities of Mytton Flags respectively, although the former species is represented in the collection by only 16 pedicle or brachial valves compared with 25 valves of the latter. Such data may be very important. They may reflect differences in the transporting capacity of sea currents. Alternatively, the *Palaeoglossa* populations may have consisted of thinly spread individuals tolerant of widely differing environments whereas *Protoskenidioides* may have existed as high density clusters of shells in rigorously circumscribed ecological niches.

Different kinds of data are required to promote investigations into the palaeo-environment on the one hand and palaeoecosystems on the other. Palaeoenvironmental studies require information on the number of each kind of valve as well as the proportion of complete to fragmented shells composing collections. This demand is well served by data prepared in the manner adopted by Temple (1968 : 9 ; 1970 : 8) for Lower Llandovery brachiopods. Yet for this approach, information on the size range frequencies of species is equally important ; and since such details cannot be derived from normal statistical tables, they are rarely available and the exercise correspondingly diminished in its efficacy. In contrast, studies of relationships within and between communities mainly require estimates of species distribution among communities ; frequencies of individuals representing a species within an association only indicate its importance according to numerical ranking. Nevertheless, such data are valuable from both palaeoecologic and stratigraphic viewpoints. Variation in the numbers of individuals present in fossil communities or their residues may be aids in determining the optimum conditions for the maintenance of a species in space, or in identifying changes in the interrelationship between species of an evolving association in time. In his study of the Shelve trilobites, Whittard (1966 : 298) illustrated variation in the number of specimens collected from each formation by time-histograms. Brachiopods pose a different problem because

TABLE I

The number of pedicle or brachial valves of the listed species recovered from 22 localities of Mytton Flags

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
<i>Apotreta</i> sp.	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-
<i>Astrorthis uniplicata</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
<i>Dalmanella elementaria</i>	-	-	-	-	-	-	-	-	13	1	-	-	-	-	1	-	-	-	-	-	2	3
<i>Desmorthis</i> ? sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
<i>Diplarelasma</i> sp.	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-
<i>Euorthisina</i> cf. <i>moesta minor</i>	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	2	-	-	2	1	-
<i>Hesperonomia</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
<i>Lenorthis</i> cf. <i>proava</i>	-	-	7	1	1	-	-	-	7	5	2	1	-	-	-	1	-	3	1	-	2	11
<i>Monobolina plumbea</i>	6	3	1	1	2	2	3	1	-	1	7	-	1	1	5	1	11	2	2	-	-	1
<i>Nocturniella</i> sp.	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Obolus</i> sp.	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-
<i>Orthis</i> cf. <i>callactis</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	2	1	-
<i>Ostrogonites</i> ? sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
<i>Palaeoglossa myttonensis</i>	1	1	1	1	-	1	2	1	1	1	1	-	-	2	-	-	1	1	-	-	-	-
<i>Paterula</i> cf. <i>bohemica</i>	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
<i>Protoshenidoides revelata</i>	-	-	-	-	-	-	-	-	16	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Pseudolingula spatula</i>	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	5
<i>Schizotreta</i> sp.	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Schmidites</i> ? <i>simplex</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>subcircularis</i>	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-

each individual is, initially at least, represented in a death assemblage by two valves so that counts of all specimens in collections consisting mainly of disarticulated valves could be a gross misrepresentation of frequencies *in vivo*. Consequently the number of individuals of listed species collected from each locality, shown in Tables 1 to 11, are the totals of, the more commonly occurring valves whether they are brachial or pedicle. Also, the tables do not include localities yielding specimens of only one species on the grounds that their distribution does not contribute to our understanding of the relationship within brachiopod associations. Such data may, however, assist in identifying those species most tolerant of palaeoenvironmental variation and have, therefore, been referred to in the explanatory text when this possibility appears to hold.

Table 1 shows the frequency distributions of various brachiopod species collected from 22 localities of Mytton Flags. The fauna was dominated by an association including *Monobolina*, *Palaeglossa* and *Lenorthis* (each also occurring alone in 5, 5 and 2 localities respectively) which was especially prevalent in unlaminated micaceous siltstones and fine-grained crystal tuffs. Another association of *Dalmanella*, *Protoskenidioides* and *Euorthisina* was characteristic of laminated siltstones and shales. The *Monobolina* association has a few elements in common with an association involving *Obolus*, *Paterula* and *Pseudolingula* found in the dark grey micaceous Hope Shales (Table 2). A similar lithofacies within the Stapeley Volcanic Group (Table 3) supported another inarticulate association with *Lingulella*, *Schmidtites* and *Schizocrania*, although *Orthis* and *Desmorthis*, which may have been constituents of an association descended from the Arenig *Dalmanella* one, occur in crystal-lithic tuffs.

TABLE 2

The number of pedicle or brachial valves of the listed species recovered from 7 localities of Hope Shales

	1	2	3	4	5	6	7
<i>Eocramatia dissimulata</i>	1	—	—	1	4	—	—
<i>Obolus subditivus</i>	—	3	1	1	—	6	1
<i>Paterula</i> cf. <i>bohemica</i>	1	1	1	—	—	1	2
<i>Pseudolingula spatula</i>	—	1	—	1	—	—	1
<i>Schizocrania salopiensis</i>	—	1	—	—	1	1	—

TABLE 3

The number of pedicle or brachial valves of the listed species recovered from 5 localities of Stapeley Shales

	1	2	3	4	5
<i>Conotreta stapeleyensis</i>	4	—	—	—	—
<i>Desmorthis</i> ? sp.	—	1	—	2	—
<i>Lingulella displosa petila</i>	—	—	1	—	1
<i>Orthis</i> sp.	—	3	—	—	—
<i>Schizocrania salopiensis</i>	—	—	1	1	—
<i>Schizotreta</i> sp.	—	—	—	1	—
<i>Schmidtites</i> ? <i>simplex subcircularis</i>	1	—	—	—	1

The succeeding Weston and Betton Beds (Tables 4, 5) consist mainly of laminated siltstones. They sustained an association which had evolved out of the Arenigian *Monobolina* complex and was evidently ancestral to the Meadowtown assemblage. In the Weston Beds, the association is dominated by *Pseudolingula*, *Palaeoglossa* and *Tissintia* with the last occurring on its own in five localities additional to those set out in Table 4. By Betton times, changes in the relative importance of species had taken place so that the association was made up mainly of *Palaeoglossa*, *Tissintia* and *Schizocrania* with each of the last two stocks constituting the only brachiopods found in three extra localities.

TABLE 4

The number of pedicle or brachial valves of the listed species recovered from 10 localities of Weston Beds

	1	2	3	4	5	6	7	8	9	10
<i>Palaeoglossa attenuata</i>	1	1	1	—	—	1	—	—	—	1
<i>Pseudolingula spatula</i>	14	2	1	1	2	1	1	—	1	2
<i>Schizocrania salopiensis</i>	1	—	—	1	3	—	—	—	—	—
<i>Schizotreta</i> ? sp.	—	—	—	—	2	—	—	—	—	—
<i>Tissintia prototypa</i>	14	—	—	—	—	—	1	15	3	4

TABLE 5

The number of pedicle or brachial valves of the listed species recovered from 11 localities of Betton Beds

	1	2	3	4	5	6	7	8	9	10	11
<i>Dalmanella salopiensis</i>	—	—	—	—	—	—	—	—	—	5	—
<i>Lingulella displosa</i>	—	—	—	—	—	1	—	—	—	—	—
<i>Palaeoglossa attenuata</i>	2	1	5	1	1	1	1	—	1	—	1
<i>Paterula</i> cf. <i>bohemica</i>	—	—	—	—	—	—	—	—	—	1	—
<i>Rafinesquina delicata</i>	—	—	—	—	—	—	—	—	—	6	—
<i>Schizocrania salopiensis</i>	1	—	—	1	1	—	—	1	1	—	—
<i>Tissintia prototypa</i>	—	1	20	—	—	—	7	2	—	—	5

The Meadowtown Beds (Table 6) are essentially laminated calcareous siltstones or fine-grained sandstones with subordinate calcarenites. This lithofacies was occupied by an association derived from the later Llanvirn ones but incorporating new elements, so that the dominant forms were *Palaeoglossa*, *Dalmanella*, *Rafinesquina*, *Tissintia* and *Pseudolingula*. *Palaeoglossa* was the only brachiopod occurring in nine additional localities. The genus must have been more tolerant of variation in the palaeoenvironment than its contemporaries because it is also the dominant member (with *Schmidtites*) of an inarticulate association, descended from the early Llanvirn communities, which includes *Lingula*, *Paterula* and *Pseudolingula* and is found in rarely occurring medium grey shales and mudstones.

The subordinate association identified in the Meadowtown Beds became overwhelmingly important in the Rorrington lithofacies which consisted of medium to dark grey slightly calcareous shales. The principal community (Table 7) was

composed of *Palaeoglossa*, *Schmidtites* and *Schizocrania* with the last genus alone occurring in six extra localities and each of the first two in an additional five. Immature shells of *Rafinesquina* are most widely distributed, followed by *Dalmanella* and *Glyptorthis*. These presumably represent unsuccessful waves of colonization by an association akin to those characteristic of the Meadowtown Beds and the succeeding calcareous Spy Wood Grit (Table 8). The Spy Wood community is dominated

TABLE 8

The number of pedicle or brachial valves of the listed species recovered from 7 localities of Spy Wood Grit

	1	2	3	4	5	6	7
<i>Bicuspina modesta</i>	—	—	4	2	1	50	12
<i>Bystromena perplexa</i>	1	2	2	—	1	8	7
<i>Dalmanella salopiensis gregaria</i>	—	3	7	2	1	76	25
<i>Drabovia</i> cf. <i>fasciostata</i>	1	—	1	—	—	12	—
<i>Glyptorthis viriosa</i>	1	—	1	1	1	21	4
<i>Harknessella</i> cf. <i>subplicata</i>	—	—	—	—	—	—	1
<i>Heterorthis</i> sp.	—	—	—	—	1	10	2
<i>Holderleyella</i> cf. <i>plicata</i>	—	—	—	—	—	3	1
<i>Kjaerina</i> (<i>Hedstroemina</i>) sp.	—	—	—	—	—	1	1
<i>Onniella</i> sp.	—	—	—	1	—	—	—
<i>Palaeoglossa attenuata</i>	1	1	—	—	—	18	4
<i>Parastrophinella musculosa</i>	—	—	—	—	—	6	2
<i>Paterula</i> cf. <i>perfecta</i>	—	3	—	1	—	4	—
<i>Platystrophia</i> cf. <i>major</i>	—	—	—	—	—	1	1
<i>Rostricellula sparsa</i>	—	—	—	—	—	5	—
<i>Salacorthis costellata</i>	—	—	1	—	—	5	2
<i>Salopia</i> cf. <i>salteri</i>	—	—	—	—	—	2	—
<i>Schizocrania salopiensis</i>	1	—	—	1	1	13	3
<i>Skenidioides</i> cf. <i>costatus</i>	—	—	4	—	—	3	—
<i>Sowerbyella multiseptata</i>	—	1	—	1	—	24	11
<i>Zygospira</i> sp.	—	—	—	—	—	1	—

by articulate brachiopods like *Dalmanella*, *Glyptorthis*, *Bystromena*, *Bicuspina* and *Sowerbyella*, although *Palaeoglossa* and *Schizocrania* persist.

The Aldress Shales, like many of the older formations, bear traces of two distinct associations (Table 9). The more commonly occurring is typified by *Paterula* and *Schmidtites* which have also been recovered from three and one extra localities respectively, and is found in medium grey micaceous siltstones. Crystal tuffs, on the other hand, supported a relatively prolific fauna dominated by *Sowerbyella*, *Dalmanella* and *Onniella*.

The fossil-bearing members of the two youngest Ordovician formations preserved in the Shelve area, the Hagley and Whittery Shales, consist mainly of light olive-grey calcareous tuffs and mudstones. However, the Whittery mudstones contain lithic and crystal fragments of volcanic debris up to 1 cm in size, mud balls and broken shells, which suggest that even those parts of the formation not obviously derived from volcanic ash falls may have been deposited by lahars. Indeed the only non-volcanic sediment appears to be a light olive-grey micaceous siltstone

TABLE 9

The number of pedicle or brachial valves of the listed species recovered from 3 localities of Aldress Shales

	I	2	3
<i>Bicuspina subquadrata</i>	—	—	1
<i>Dalmanella salopiensis transversa</i>	—	1	33
<i>Heterorthis</i> sp.	—	—	1
<i>Horderleyella</i> sp.	—	—	7
<i>Onniella ostentata lepida</i>	—	2	22
<i>Orthambonites</i> sp.	—	—	1
<i>Palaeoglossa attenuata</i>	1	—	—
<i>Paterula</i> cf. <i>perfecta</i>	1	—	—
<i>Petrocrania dubia</i>	—	—	1
<i>Platystrophia</i> cf. <i>major</i>	—	—	1
<i>Plectorthis</i> sp.	—	—	1
<i>Rafinesquina</i> sp.	—	—	1
<i>Schmidtites</i> ? <i>simplex</i>	1	—	—
<i>Sowerbyella sericea permixta</i>	—	2	66

occurring in the Hagley Shales. This lithofacies bears *Sericoidea*, while the rest of the formation contains an association descended from that occurring in the Aldress tuffs but with *Onniella* and *Reuschella* dominant, *Sowerbyella* playing a subordinate role and *Dalmanella* no longer occurring (Table 10). This fauna attained its full

TABLE 10

The number of pedicle or brachial valves of the listed species recovered from 4 localities of Hagley Shales

	I	2	3	4
<i>Bicuspina subquadrata</i>	—	—	1	1
<i>Caeroplecia plicata</i>	—	—	—	1
<i>Kiaeromena</i> sp.	2	—	—	—
<i>Leptaena</i> cf. <i>ventricosa</i>	2	1	—	—
<i>Nicolella</i> cf. <i>actoniae</i>	—	—	—	1
<i>Onniella ostentata lepida</i>	4	1	1	3
<i>Orthambonites</i> sp.	1	—	—	1
<i>Parastrophinella</i> sp.	—	—	—	1
<i>Petrocrania dubia</i>	—	—	—	1
<i>Platystrophia caelata</i>	1	—	—	1
<i>Plectorthis whitteryensis</i>	—	—	—	2
<i>Reuschella horderleyensis carinata</i>	1	—	2	1
<i>Salopia</i> sp.	—	—	—	1
<i>Sericoidea</i> cf. <i>abditia</i>	—	10	—	—
<i>Sowerbyella</i> cf. <i>sericea</i>	2	—	—	2

diversity in the Whittery mudstones where *Bicuspina*, *Caeroplecia*, *Nicolella*, *Onniella*, *Orthambonites*, *Reuschella* and *Whittardia* are very common (Table 11). Many constituents, including *Caeroplecia*, *Nicolella*, *Orthambonites*, *Palaeostrophomena* and *Platystrophia*, reveal that the fauna is mainly composed of the *Nicolella*

TABLE II

The number of pedicle or brachial valves of the listed species recovered from 4 localities of Whittery Shales

	I	2	3	4
<i>Bicuspina subquadrata</i>	2	1	17	15
<i>Caeroplecia plicata</i>	3	—	14	7
<i>Dolerorthis</i> cf. <i>tenuicostata</i>	—	—	3	—
<i>Furcitella</i> sp.	—	—	1	—
<i>Glyptorthis viriosa</i>	—	—	2	—
<i>Kiaeromena</i> sp.	1	—	—	—
<i>Leptaena</i> cf. <i>ventricosa</i>	—	1	1	1
<i>Mcewanella</i> sp.	—	—	—	2
<i>Nicolella actoniae</i>	3	9	6	5
<i>Onniella ostentata lepida</i>	4	3	9	25
<i>Orthambonites exopunctata</i>	4	7	12	11
<i>Palaeoglossa attenuata</i>	1	—	—	—
<i>Palaeostrophomena</i> sp.	1	1	1	—
<i>Petrocrania dubia</i>	—	—	1	3
<i>Platystrophia caelata</i>	1	2	2	2
<i>Plectorthis whitteryensis</i>	—	—	7	2
<i>Rafinesquina</i> sp.	—	—	1	—
<i>Reuschella horderleyensis carinata</i>	12	11	6	3
<i>Salopia</i> sp.	—	—	2	1
<i>Skenidioides</i> cf. <i>costatus</i>	1	—	2	1
<i>Sowerbyella</i> cf. <i>sericea</i>	2	1	1	8
<i>Triplesia</i> sp.	—	—	—	1
<i>Whittardia paradoxica</i>	3	—	8	2

association (Williams 1973: 242), but elements like *Bicuspina* and *Leptaena* further suggest that remnants of the *Dinorthis* association may also be present.

In conclusion, it is noteworthy that the composition of brachiopod assemblages collected from the Ordovician succession of Shelve appears to be closely connected with the nature of the entombing sediments. In general, two main groups seem to be involved: an inarticulate association connected with the finer clastic sediment and a predominantly articulate one sustained in the coarser, banded, sporadically calcareous siltstones or fine sandstones. Both associations may be traced throughout much of the Ordovician succession with one dominant over the other. Both show profound changes in the composition and relative importance of their constituent taxa and, thereby, greatly reduce the prospects for precise interprovincial correlation.

IV. SYSTEMATIC METHODS

The procedure adopted during the systematic study of the Shelve brachiopods was to quantify, wherever possible, any morphological variation displayed by conspecific specimens from any one locality or horizon and evaluate differences detected among congeneric samples by standard statistical tests for significance. This method is similar to that used by the writer during researches on Girvan and Bala faunas (Williams 1962: 69-79; 1963: 333), and requires only a few words of explanation.

The number of individuals attributable to any species represented in the collection is small enough to warrant not only the invariable use of small sample techniques but, for many taxa, nothing more than the mean (or mode) and range of variability. Continuous univariate characters which are assumed to be normally distributed, like the distances at which folds originate anterior of umbones or the wavelengths of ribs at a given distance antero-medially of the umbo, have been compared by the *t*-test. Discontinuous univariate characters, like the number of costae ornamenting valves or the relative branching of costellae enumerated according to Bancroft's notation (Bancroft 1945 : 186 ; Williams 1962 : 77), have been compared by χ^2 tests, or contingency or two-by-two tables dependent on the size of samples.

Continuous variables derived by measuring the shell or its several parts, like the cardinalia, dental plates or muscle impressious, are expressions of incremental proportional growth, which may or may not be allometric, and all show very high positive (or rarely negative) correlations with one another. The significance of any differences in estimates of such parameters has been determined by statistical analysis of a series of bivariate distributions. The method is adequate for the comparison of such closely inter-related estimates of shell growth. It also has the advantage of not obscuring the identity of those characters that underwent changes in the rate of growth during cladogenetic or phylogenetic speciation. The development of significantly longer dental plates in one of a number of compared species, for example, will be apparent whether the lengths of plates are consistently paired with the lengths, maximum widths or depths of the pedicle valves in compared samples.

In estimating variation in outline, shape and relative size of the brachiopod skeleton, very many measurements in almost any plane or direction may be taken, provided the same disposition is adopted in measuring all individuals in compared samples. However, certain orientations for the measurement of shells or their impressions have become widely favoured by brachiopod researchers over the years

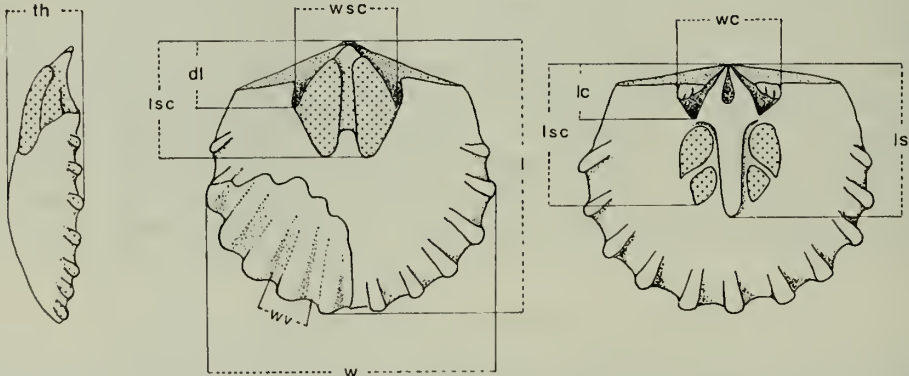


FIG. 3. Diagrammatic representation of moulds (and adherent shell) of *Orthambonites* to show the orientation adopted for measuring certain dimensions including : length (l), maximum width (w) and thickness (th) of a valve, the wavelength of a costa (wv), the length of dental plates (dl), the length (lsc) and width (wsc) of muscle scars, the length of a median ridge (ls), and the length (lc) and width (wc) of brachiophore bases.

and may be regarded as standard. These include length (sagittal), width (maximum) and depth (maximum). Certain orientations for the measurement of internal features are also coming into general use although they have not yet been standardized. Those used in this paper are illustrated in Text-fig. 3, in relation to internal moulds which lend themselves very well to estimating the forward extensions of the bases of dental plates, brachiophores and sockets, or of muscle scars.

V. SYSTEMATIC PALAEOLOGY

Class *INARTICULATA* Huxley 1869

Order LINGULIDA Waagen 1885

Superfamily LINGULACEA Menke 1828

Family OBOLIDAE King 1846

Subfamily OBOLINAE King 1846

OBOLUS Eichwald 1829

Obolus subditivus sp. nov.

(Pl. I, figs. 1-8)

DIAGNOSIS. Biconvex, subcircular *Obolus* almost as long as wide with a lenticular ventral pseudointerarea extending anteriorly for 15% of the length of the pedicle valve and a dorsal pseudointerarea not divided into propareas by an identifiable median groove.

DESCRIPTION. Subcircular, biconvex, *Obolus* with a mean length relative to width of 95% (range 83% to 111%) and a mean depth relative to length of 14% (range 12% to 17%) for 6 pedicle valves, and a brachial valve about one-tenth as deep as long, both valves evenly convex transversely but flattened slightly anteriorly; beaks marginal; shell surface ornamented by concentric growth lines and up to 10 impersistent low narrow plicae.

Striated pseudointerarea of pedicle valve lenticular in outline, orthocline to anacline in attitude, extending forward for 15% of the length of 6 pedicle valves (range 12% to 20%) and divided into 2 propareas by a shallow pedicle groove bearing a fine low median ridge; ventral muscle impressions unknown.

Striated pseudointerarea of brachial valve obtusely triangular, orthocline, extending forward for only one-twentieth of the length of the brachial valve, median groove not identifiable; a pair of elongate muscle scars, possibly representing lateral muscle bases, are vaguely impressed on either side of a low obscure median ridge.

TYPE MATERIAL.

		length	width (mm)
HOLOTYPE	External and internal moulds of pedicle valve (BB 35573a, b)	5.0	4.6
PARATYPES	External and internal moulds of pedicle valve (BB 35574a, b)	3.3	3.1
	External and internal moulds of brachial valve (BB 35575a, b)	3.8	3.8

HORIZON AND LOCALITY. Hope Shales exposed in path west of Brithdir Farm, 1 mile ENE of Old Church Stoke (Grid Ref. SO 300953).

DISCUSSION. The attribution of relatively small obolids found in the Hope Shales to *Obolus* s.s. is a matter of convenience until more is known about the musculature of the new species, which was not accommodated by well-developed platforms as in more typical species. Even the identification of the species as an obolinid may be a matter of dispute because the dorsal pseudointerarea does not bear an identifiable median groove although it is certainly a better developed feature than the striated thickening of the posterior margin characteristic of the glossellinid brachial valve. In respect of both features, the new species differs from orthodox *Obolus*. However, Cooper (1956: 189-193) assigned a few species to the genus which bear some resemblance to *O. subditivus*. This is especially true of *O. ? biconvexa* Cooper from the Lower Paperville Formation of Tennessee and the closely related *O. ? nitens* Cooper from the Lower Rich Valley Formation of Virginia, although both are more elliptically elongate and lack radial plicae, while the former is further distinguished by the presence of concentric undulations.

Obolus sp.

(Pl. 1, figs. 9, 10)

In contrast to *O. subditivus* sp. nov., a few exfoliated valves have been recovered from the Mytton Flags, which are more representative of typical *Obolus*. The exposures in Bergam Quarry above Tankerville Mine (Grid Ref. SO 355995) have yielded an evenly convex pedicle valve (BB 35581a, b) about 6 mm long, which is transversely oval in outline with a length about 70% of the width and a depth 25% of the length. A heart-shaped postero-medial portion of the valve has broken away and probably constitutes the muscle platform. No identifiable impressions are preserved on the internal mould of the platform but a well-defined pedicle groove is seen medially indenting a relatively narrow pseudointerarea.

Another incomplete specimen (BB 35582) about 8 mm wide and over 1 mm deep has been collected from near an adit 290 yds. west of Wood House (Grid Ref. SJ 336002). It bears a pair of submedial muscle scars and may be the brachial valve of the same species. Even so, paucity of material precludes specific identification.

SCHMIDTITES Schuchert & Le Vene 1929

Schmidtites ? simplex sp. nov.

(Pl. 1, figs. 11-15)

DIAGNOSIS. Subequally biconvex, circular obolids with valves almost as long as wide and 10% as deep as long, ornamented by fila and overlapping lamellae; pseudointerareas narrow, probably striated and divided by relatively wide pedicle groove and median dorsal depression.

DESCRIPTION. Subequally biconvex, circular obolids with inconspicuous beaks and valves 99% as long as wide and 10% as deep as long; ornamented by strong fila,

becoming less distinct medially, and finely developed overlapping lamellae ; however the thin shell is usually preserved in a collapsed state commonly expressed as transverse or even radiating wrinkles.

Ventral interior with a narrow crescentic striated pseudointerarea divided by a relatively wide pedicle groove ; muscle impressions known only in one specimen as a pair of suboval, submedial scars, possibly flanked by another set, distinguishable as smooth areas in a finely pitted internal surface.

Dorsal pseudointerarea with a very narrow thickened zone along the posterior margin which may represent a medially grooved pseudointerarea ; other internal features unknown although a low median ridge extends forwards for three-quarters the length of some valves.

TYPE MATERIAL.

		length	width (mm)
HOLOTYPE	External and internal moulds of pedicle valve (BB 37134a, b)	4.5	4.5
PARATYPES	External and internal moulds of brachial valve (BB 37135a, b)	3.0	2.7
	Exterior of pedicle valve (BB 37136)	3.5	4.0
	External and internal moulds of pedicle valve (BB 37137a, b)	2.6	—
	Internal mould of brachial valve (BB 37138)	4.2	4.5
	Internal mould of pedicle valve (BB 37139)	4.0	—
	External and internal moulds of pedicle valve (BB 37140a, b)	3.5	3.5

HORIZON AND LOCALITIES. Rorrington Beds : BB 37134, 37138 from exposures in Holywell Brook 160 yds WNW of the Mount, Rorrington (Grid Ref. SJ 299007) ; BB 37135, 37139 from outcrops in Deadman's Dingle 100 ft upstream from junction with Spy Wood Brook (Grid Ref. SO 280960) ; BB 37136 from exposures 60 yds north-west of the Mount, Rorrington (Grid Ref. SJ 302005) ; BB 37137, 37140 from the tributary to Lower Wood Brook 340 yds south-east of Desert (Grid Ref. SJ 308017).

Schmidtites ? simplex subcircularis sp. et subsp. nov.

(Pl. 1, figs. 16, 17 ; Pl. 2, fig. 1)

DIAGNOSIS. Like *Schmidtites ? simplex* but subcircular with valves 96% as wide as long and 7% as deep as long ; protegulum semicircular about 0.2 mm long.

TYPE MATERIAL.

		length	width (mm)
HOLOTYPE	Exterior of pedicle valve (BB 37141)	2.5	2.8
PARATYPES	External and internal moulds of pedicle valve (BB 37142a, b)	3.0	3.0
	External and internal moulds of brachial valve (BB 37143a, b)	3.3	3.6

HORIZON AND LOCALITY. All specimens from Stapeley Shales exposed in Whitsburn Dingle 650 yds WSW of Lord's Stone, Leagh (Grid Ref. SJ 328019).

DISCUSSION. Subcircular inarticulates, occurring fairly abundantly in the Stapeley Shales and the Meadowtown and Rorrington Beds, are provisionally assigned to the obolid genus *Schmidtites* only because of the lack of muscle platforms which are normally elaborate structures in other obolinids. With regard to the modest differentiation of the posterior margins, here interpreted as poorly developed pseudo-interareas, the new species differs even from other described *Schmidtites*, and may eventually prove to be generically separable from all other lingulaceans, to which superfamily it almost certainly belongs.

Notwithstanding the obscurity of internal features and simplicity of shape, the conspecific Meadowtown and Rorrington samples are significantly different ($p < 0.02$) from specimens recovered from the Stapeley Shales which became progressively longer than wide during growth (Table 12). The difference has been recognized by the erection of a new subspecies.

TABLE 12

Statistics of length (l) and maximum depth (w) of n pedicle valves of *Schmidtites* ? *simplex* sp. nov. from the Rorrington Beds (A) and the Meadowtown Beds (B), and of *Schmidtites* ? *simplex subcircularis* sp. et subsp. nov. from the Stapeley Shales (C)

	A	B	C
n	29	20	9
l mm (var l)	2.88 (1.148)	2.98 (1.235)	3.13 (3.23)
w mm (var w)	2.9 (1.145)	3.01 (1.244)	3.00 (1.952)
r	0.995	0.977	0.986
$\frac{r}{\log_e l}$ (var $\log_e l$)	0.9927 (0.1296)	1.0288 (0.1296)	0.1 (0.2844)
$\frac{r}{\log_e w}$ (var $\log_e w$)	0.9996 (0.1279)	1.0358 (0.129)	1.0004 (0.1963)
r_e	0.995	0.979	0.99
α (var α)	0.9931 (0.00037)	0.9975 (0.00231)	0.8307 (0.00195)

Subfamily **LINGULELLINAE** Schuchert 1893

LINGULELLA Salter 1866

Lingulella displosa sp. nov.

(Pl. 2, figs. 2-8)

DIAGNOSIS. Ventriconvex, elongately oval to subtriangular *Lingulella* with a brachial valve 87% as wide as long and a pedicle valve up to 13% as deep as long, ornamented by impersistent concentrically arranged lamellae, pedicle groove and dorsal pseudointerarea extending anteriorly for 9% and 7% to the valve length respectively.

DESCRIPTION. Ventriconvex *Lingulella* normally changing in outline from elongately oval to subtriangular with a broadly rounded to truncated anterior margin by an acceleration in antero-lateral shell accretion during adult growth stages; brachial valve 87% as wide and less than 10% as deep as long, pedicle valve about 13% as deep as long and 87% as wide as long (range 77% to 97% for 6 specimens),

both valves evenly convex in longitudinal and transverse profiles ; external surface ornamented by concentrically disposed impersistent lamellae giving a finely scalloped appearance ; ventral beak acute, dorsal beak obtusely rounded.

Ventral pseudointerarea striated, slightly anacline to orthocline, crescentic in outline and divided into 2 curved propleas by a shallow, relatively wide pedicle groove extending forward for 9% of the valve length ; umbonal muscle scars suboval located immediately anteriorly of the propleas ; 2 short, low ridges narrowly diverge from the anterior end of the pedicle groove.

Dorsal pseudointerarea striated, orthocline, lenticular in outline and extending forward for 7% of the length of the brachial valve ; dorsal muscle impressions unknown ; postero-medial internal surfaces of both valves sporadically and shallowly pitted.

TYPE MATERIAL.

		length	width (mm)
HOLOTYPE	Incomplete external and internal moulds of pedicle valve (BB 37144a, b)	14·0	11·5
PARATYPES	External and internal moulds of pedicle valve (BB 37146a, b)	12·0	10·0
	External and internal moulds of brachial valve (BB 37147a, b)	15·0	11·0
	External and internal moulds of pedicle valve (BB 37148a, b)	14·0	12·0
	Internal mould of brachial valve (BB 37149)	14·5	14·0

HORIZONS AND LOCALITIES. Meadowtown Beds: BB 37144 from exposures 80 yds from Meadowtown Quarry along the Rorrington road (Grid Ref. SJ 311012) ; BB 37146 from a small excavation in the corner of a field alongside the cart-track from Meadowtown to Waitchley 330 yds due south of Waitchley (Grid Ref. SJ 311017) ; BB 37147 from outcrops 570 yds south-west of Meadowtown Quarry (Grid Ref. SJ 306009) ; BB 37148 from outcrops along the lane to Lower Ridge from bench mark 754, Little Weston (Grid Ref. SO 293984) ; BB 37149 from Rorrington Beds exposed in Lower Wood Brook 400 ft south-east of the Meadowtown-Rorrington road (Grid Ref. SJ 307008).

Lingulella displosa petila sp. et subsp. nov.

(Pl. 2, figs. 9-11 ; Pl. 3, fig. 1)

DIAGNOSIS. Gently biconvex, suboval *Lingulella* with a brachial valve 70% as wide as long, ornamented by impersistent concentrically arranged lamellae, pedicle groove and dorsal pseudointerarea extending anteriorly for 13% and 8% of the valve length respectively.

DESCRIPTION. Subequally biconvex *Lingulella* normally suboval in outline with well-rounded anterior margins and a maximum width at about 60% of the shell length anterior of the umbones ; pedicle valve about 5% as deep as long and, on average, 70% as wide as long (range 63% to 80% for 5 specimens), both valves

gently and evenly convex in longitudinal and transverse profiles; external surface ornamented by concentrically disposed impermanent lamellae giving a finely scalloped appearance; ventral beak sharply acute, dorsal beak less conspicuous and more rounded.

Ventral pseudointerarea striated, anacline to orthocline, crescentic in outline and divided into two obliquely disposed propareas by a shallow pedicle groove extending forward for about 13% of the valve length; ventral muscle impressions unknown.

Dorsal pseudointerarea striated, orthocline, lenticular in outline and extending forward for 5% of the valve length; dorsal muscle impressions unknown; fine median ridge faintly developed for over half the valve length, postero-medial internal surfaces of both valves sporadically and shallowly pitted.

TYPE MATERIAL.

		length	width (mm)
HOLOTYPE	External and internal moulds of pedicle valve (BB 37150a, b)	10.0	6.0
PARATYPES	External and internal moulds of brachial valve (BB 37151a, b)	8.0	6.0
	External and internal moulds of pedicle valve (BB 37152a, b)	-	6.0

TYPE HORIZON AND LOCALITY. All specimens from the Stapeley Volcanic Group exposed in Whitsburn Dingle, 650 yds WSW of Lord's Stone, Leagh (Grid Ref. SJ 328019).

DISCUSSION. Ordovician *Lingulella* from the Shelve area appear to differ from other known *Lingulella* in being ornamented by finely scalloped lamellae. The pattern is reminiscent of *Glyptoglossella* although in other respects, notably the presence of a dorsal pseudointerarea, the specimens cannot even be assigned to the same sub-family. The change in outline from oval to subtriangular that took place during the

TABLE 13

Statistics of length (l) and maximum width (w) of n brachial valves of *Lingulella displosa* sp. nov. from the Rorrington Beds (A) and the Meadowtown Beds (B)

	A	B
n	12	8
l mm (var l)	8.84 (14.383)	8.05 (25.209)
\bar{w} mm (var w)	8.6 (13.647)	6.97 (19.902)
r	0.986	0.97
a (var a)	0.9741 (0.00269)	0.8885 (0.00774)

TABLE 14

Statistics of length (l) and maximum depth (w) of 8 pedicle valves of *Lingulella displosa* sp. nov. from the Rorrington Beds

l mm (var l)	4.76 (8.931)
\bar{w} mm (var w)	4.37 (8.494)
r	0.994
a (var a)	0.9752 (0.00184)

growth of *L. displosa* is also unusual, although a similar acceleration in growth along antero-lateral vectors was responsible for the subtriangular appearance of adult shells of the Tremadocian *L. lingulaeformis* (Mickwitz) from the Baltic area (Goryanski 1969 : 38), the mid-Ordovician *L. decorticata* Cooper from the Elway Formation of Virginia, and *L. rideanensis* Cooper from the Aylmer Formation of Ontario (Cooper 1956 : 198, 203). All three species, however, are described as having an ornamentation consisting solely of fine concentric lines.

Lingulella collected from the Meadowtown and Rorrington Beds are indistinguishable in every respect (Tables 13, 14) and constitute *L. displosa* s.s. The small sample derived from the Stapeley Shales, on the other hand, differs significantly in the relative narrowness and very gentle biconvexity of the shell and in the trace of a fine median septum in the brachial valve. These differences have prompted the erection of a new taxon, but to indicate its essential affinity with the Meadowtown and Rorrington forms this is at the subspecific level only.

PALAEOGLOSSA Cockerell 1911 emended A. W.

1848 *Glossina* Phillips : 370 ; non Wiedemann 1830.

1911 *Palaeoglossa* Cockerell : 96.

1956 *Palaeoglossa* Cockerell ; Cooper : 194.

1965 *Palaeoglossa* Cockerell ; Rowell in Williams *et al.* : H270.

DIAGNOSIS. Elongately oval, biconvex lingulellinids ornamented by fine discontinuous fila with the dorsal pseudointerarea not differentiated into propareas.

DESCRIPTION. Elongately oval, biconvex lingulellinids with an acute curved ventral beak ; surface ornamented by fine fila in addition to growth lines ; ventral pseudointerarea slightly anacline divided by a narrow pedicle groove into striated propareas with strong flexure lines, dorsal pseudointerarea orthocline, striated, lenticular in outline and not divided into propareas ; low median ridge sporadically developed in the brachial valve ; muscle impressions unknown except for traces of a pair of umbonal muscle scars immediately anterior of the pseudointerareas of both valves.

TYPE SPECIES. *Lingula attenuata* J. de C. Sowerby in Murchison 1839.

TYPE HORIZON. Meadowtown Beds.

DISCUSSION. Well-preserved valves from the Meadowtown Beds afford an opportunity to learn more about the internal morphology of the topotypic *Lingula attenuata* Sowerby which is the type species of *Palaeoglossa* Cockerell (*nom. subst. pro Glossina* Phillips 1848). The presence and degree of differentiation of the pseudointerareas indicate that the genus is best accommodated among the Lingulellinae. Indeed in the absence of information about the principal muscle scars, *Palaeoglossa* differs from *Lingulella* only in details. They include the greater biconvexity, the more incurved beaks and the more elongately oval outline of *Palaeoglossa*, and possibly the skeletal structure, because the *Palaeoglossa* shell tends to be more laminar and its inner layers are not radially striated as in *Lingulella*. Differences between *Palaeoglossa* and *Pseudobolus* Cooper (1956 : 194) as currently understood are even

more finely drawn; and when the internal features of the latter genus become known, it may prove to be a junior synonym of *Palaeoglossa*.

Palaeoglossa attenuata (Sowerby) emended A. W.

(Pl. 3, figs. 2-13)

1839 *Lingula attenuata* Sowerby in Murchison: 641.

1866 *Lingula attenuata* Sowerby; Davidson: 44.

DIAGNOSIS. Subequally biconvex *Palaeoglossa* with a brachial valve 73% as wide and 6% as deep as long and a pedicle valve 71% as wide and 7% as deep as long; fila fine and discontinuous; ventral pseudointerarea with a shallow narrow pedicle groove extending anteriorly for 11% of the length of the pedicle valve, and a dorsal pseudointerarea and low median ridge extending forward for 7% and 43% of the brachial valve length respectively.

DESCRIPTION. Subequally biconvex, elongately oval *Palaeoglossa* with curved lateral and rounded anterior margins, brachial valve 73% as wide as long and 6% as deep as long (with a range of 3% to 8% for 9 valves), pedicle valve 71% as wide as long and 7% as deep as long, both valves evenly convex in longitudinal and transverse profiles; external surface ornamented by growth lines and fine discontinuous fila about 0.25 mm in wavelength; ventral beak acutely incurved, dorsal beak obtusely rounded.

Ventral pseudointerarea striated, slightly anacline, crescentic in outline, 11% as long medially as the length of the valve, pedicle trough narrow and shallow; divided umbonal muscle scars rarely impressed.

Dorsal pseudointerarea striated, almost orthocline, lenticular in outline and extending forward medially for 7% of the length of the valve (range 6% to 8% for 6 specimens); divided umbonal muscle scars rarely impressed on either side of a low variably developed median ridge extending anteriorly for 43% of the length of the valve (range 28% to 66% for 5 specimens).

FIGURED MATERIAL.

	length	width (mm)
External and internal moulds of brachial valve (BB 37109a, b)	11.0	8.0
External and internal moulds of pedicle valve (BB 37110a, b)	7.0	5.0
External and internal moulds of pedicle valve (BB 37111a, b)	12.5	8.7
Exterior of pedicle valve (BB 37112)	8.3	6.0
Exterior of pedicle valve (BB 37113)	6.5	4.5
External and internal moulds of brachial valve (BB 37114a, b)	13.0	9.0
Internal mould of pedicle valve (BB 37115)	16.0	—
External and internal moulds of pedicle valve (BB 37116a, b)	5.5	3.6
External and internal moulds of disarticulated valves (BB 37117a, b)	5.5	3.0
External and internal moulds of brachial valve (BB 37118a, b)	12.0	9.0

HORIZONS AND LOCALITIES. Meadowtown Beds: BB 37111, 37114 from outcrops on the Meadowtown-Rorrington road, 220 yds from Meadowtown Chapel (Grid Ref.

SJ 309012); BB 37113, 37115 from outcrops 80 yds from Meadowtown Quarry along Rorrington road (Grid Ref. SJ 311013); BB 37110 from outcrops along lane to Lower Ridge from benchmark 754, Little Weston (Grid Ref. SO 293984); BB 37109 from outcrops in Lower Wood Brook 400 ft south-east of the Meadowtown-Rorrington road (Grid Ref. SJ 307008); BB 37112 from laneside exposures 370 yds north of Meadowtown Chapel (Grid Ref. SJ 311015). Betton Beds: BB 37116, 37117 from outcrops downstream of junction between Holywell and Whitehouse Brooks (Grid Ref. SJ 303004); exact locality of BB 37116 uncertain. Rorrington Beds: BB 37118 from exposures in a stream 530 yds north-west of Meadowtown Chapel (Grid Ref. SJ 308017).

Palaeoglossa myttonensis sp. nov.

(Pl. 4, figs. 1-5)

DIAGNOSIS. Ventribiconvex *Palaeoglossa* with a brachial valve 78% as wide and 4% as deep as long and a pedicle valve about twice as deep; fila fine and normally continuous; dorsal pseudointerarea lenticular and restricted to the umbonal area, dorsal median septum extending anteriorly for about half the valve length; postero-medial internal surfaces of shell sporadically and shallowly pitted.

DESCRIPTION. Ventribiconvex, oval *Palaeoglossa* with curved lateral and rounded anterior margins; brachial valve 78% as wide and 4% as deep as long, pedicle valve about 8% as deep as long; both valves evenly convex in longitudinal and transverse profiles; surfaces ornamented by growth lines and fine, somewhat distant, more or less continuous fila with a wavelength of about 0.25 mm.

Ventral pseudointerarea striated, slightly anacline, crescentic, divided by a shallow pedicle trough extending anteriorly for 11% of the length of the valve.

Dorsal pseudointerarea striated, slightly anacline, lenticular in outline, restricted to the umbonal area and extending anteriorly for 9% of the valve length; dorsal median ridge low, extending forward for 51% of the valve length (range 47% to 54% for 5 specimens); postero-medial internal surfaces of both valves sporadically and shallowly pitted.

TYPE MATERIAL.

		length	width (mm)
HOLOTYPE	External and internal moulds of conjoined valves (BB 37119)	—	4.5
PARATYPES	Incomplete external and internal moulds of brachial valve (BB 37121a, b)	—	—
	External and internal moulds of slightly disarticulated valves (BB 37122a, b)	6.5	5.0
	Internal mould of brachial valve (BB 37123)	6.5	5.2

HORIZON AND LOCALITIES. Mytton Flags: BB 37119, 37122 from tip heaps on road to Squilver 150 yds ENE of Whitegrit School (Grid Ref. SO 323976); BB 37121 from sides of adit of New Perkin's Level (Grid Ref. SJ 376022); BB 37123 from

outcrops near the top of steep tributary to Crowsnest Dingle, 350 yds WNW from Blakemoorflat (Grid Ref. SJ 373008).

DISCUSSION. Representatives of *Palaeoglossa* have been recovered from most formations constituting the Ordovician successions of the Shelve area, but samples giving some indication of the variability in the shape of the shell and the development of internal features have been obtained from only the Mytton Flags and the

TABLE 15

Statistics of length (l) and maximum width (w) of n brachial valves of *Palaeoglossa attenuata* (J. de C. Sowerby) from Meadowtown Beds (A) and the Rorrington Beds (B) and of *Palaeoglossa myttonensis* sp. nov. from the Mytton Flags (C)

	A	B	C
n	29	14	10
l mm (var l)	9.31 (11.789)	5.01 (16.285)	5.42 (2.813)
\bar{w} mm (var w)	6.82 (6.243)	3.53 (7.37)	4.19 (1.93)
r	0.951	0.994	0.981
a (var a)	0.7277 (0.00186)	0.6727 (0.00045)	0.8283 (0.00321)

TABLE 16

Statistics of length (l) and maximum width (w) of n pedicle valves of *Palaeoglossa attenuata* (J. de C. Sowerby) from the Meadowtown Beds (A), the Rorrington Beds (B) and the Betton Beds (C)

	A	B	C
n	32	36	23
l mm (var l)	10.76 (28.081)	5.8 (11.584)	5.09 (1.589)
\bar{w} mm (var w)	7.67 (17.835)	4.23 (6.518)	3.23 (0.67)
r	0.982	0.984	0.918
$\overline{\log_e l}$ (var $\log_e l$)	2.2667 (0.2173)	1.6098 (0.2958)	1.5978 (0.0594)
$\overline{\log_e w}$ (var $\log_e w$)	1.9051 (0.2646)	1.2872 (0.3104)	1.1431 (0.0618)
r_e	0.985	0.9871	0.925
α (var α)	1.1036 (0.0012)	1.0244 (0.00079)	1.0203 (0.00718)

TABLE 17

Statistics of length (l) and maximum depth (th) of 9 pedicle valves of *Palaeoglossa attenuata* (J. de C. Sowerby) from the Meadowtown Beds

l mm (var l)	10.34 (9.89)
th mm (var th)	0.77 (0.087)
r	0.964
a (var a)	0.094 (0.00008)

TABLE 18

Statistics of length (l) and length of ventral pseudointerarea (pl) of 7 pedicle valves of *Palaeoglossa attenuata* (J. de C. Sowerby) from the Meadowtown Beds

l mm (var l)	13.5 (66.00)
pl mm (var pl)	1.43 (0.789)
r	0.909
a (var a)	0.1093 (0.00041)

Betton, Meadowtown and Rorrington Beds. The Meadowtown assemblage is topotypic with those specimens on which J. de C. Sowerby (in Murchison 1839 : pl. xxii, fig. 13) based *P. attenuata*. Comparisons of internal features like the relative anterior extension of the pseudointerareas and the dorsal median ridge, as well as the depth and outline of the valves (Tables 15–18), show that those *Palaeoglossa* recovered from the Betton and Rorrington Beds are indistinguishable from *P. attenuata*.

The small sample taken from the Mytton Flags, on the other hand, differs from the others in the significantly greater expansion in width relative to length during shell growth (Table 15). The beak of the brachial valve is also more acutely rounded and the lenticular pseudointerarea correspondingly more restricted to the umbonal region, while the sporadically distributed shallow pits indenting the postero-medial internal surfaces of the Mytton shells have not been seen in younger specimens. These differences merit specific recognition ; and it is interesting to note that the new species appears to be restricted in stratigraphic distribution because the few specimens of *Palaeoglossa* known from the Weston, Spy Wood and Whittery Formations are best assigned to *attenuata*.

Subfamily GLOSSELLINAE Cooper 1956

PSEUDOLINGULA Mickwitz 1909 emended A. W.

1909 *Pseudolingula* Mickwitz : 771.

1945 *Pseudolingula* Mickwitz ; Sinclair : 58.

1965 *Pseudolingula* Mickwitz ; Rowell in Williams *et al.* : H267.

1969 *Pseudolingula* Mickwitz ; Goryanski : 41.

DIAGNOSIS. Biconvex, parallel-sided glossellinids ornamented by fila with an orthocline ventral pseudointerarea divided by a pedicle groove into two striated propareas and an undifferentiated dorsal posterior margin ; umbonal muscle scars divided, other muscle bases, including identifiable lateral and transmedian sets, supported on a broad adnate platform in the pedicle valve and impressed on either side of a median septum in the brachial valve ; interiors sporadically pitted postero-medially.

DISCUSSION. Well-preserved internal moulds of *Pseudolingula* recovered from the Ordovician rocks of the Shelve area reveal more details of the internal morphology of this genus than have hitherto been recorded, and allow for a reappraisal of its position within the lingulide hierarchy. All characters confirm the lingulacean affinities of the taxon, and the divided aspect of the umbonal muscle bases indicates that it is best assigned to the Obolidae. This allocation is corroborated by the development of a pedicle groove bounded by flexures and striated propareas at least in the specimens from the Rorrington Beds. The undifferentiated dorsal posterior margin, however, suggests that *Pseudolingula* is closer to the Glossellinae than the Lingulellinae as currently conceived (see Rowell in Williams *et al.* 1965 : H266–269), and its transference to the former subfamily is accordingly adopted for this study.

Pseudolingula spatula sp. nov.

(Pl. 4, figs. 6-14; Pl. 5, fig. 1; Text-fig. 4)

DIAGNOSIS. Subequally biconvex, subquadrate *Pseudolingula* with a brachial valve 67% as wide and 5% as deep as long, ornamented by strong fila laterally, becoming finer medially, and bearing an adnate ventral muscle platform and a strong dorsal median ridge arising up to one-fifth anteriorly of the beak and extending forwards 58% of the length of the valve.

DESCRIPTION. Subequally biconvex, subquadrate *Pseudolingula* with parallel lateral and obtusely rounded anterior margins and obtuse beaks with the more rounded dorsal one subtending an angle of about 100° ; brachial valve 67% as wide and about 5% as deep as long; both valves subcarinate postero-medially but flattening laterally and anteriorly; external surface ornamented by growth lines and fila which are strongly developed with a wavelength of about 0.2 mm laterally but tending to become finer medially.

Ventral interior with median depression to accommodate pedicle but nature of the propareas unknown; umbonal muscles divided and represented by elongately oval scars on either side of the median depression, other muscle bases not identifiable individually but supported on a broad medially pointed platform, heavily rutted by growth lines and extending forward of the beak for about two-fifths of the length of the pedicle valves.

Dorsal interior with median depression at the beak but posterior margin undifferentiated; median septum arising up to one-fifth of the valve length anterior of the beak and becoming strong and relatively high at the anterior end which is, on average, 58% of the valve length forward of the dorsal beak (range 54% to 61% for

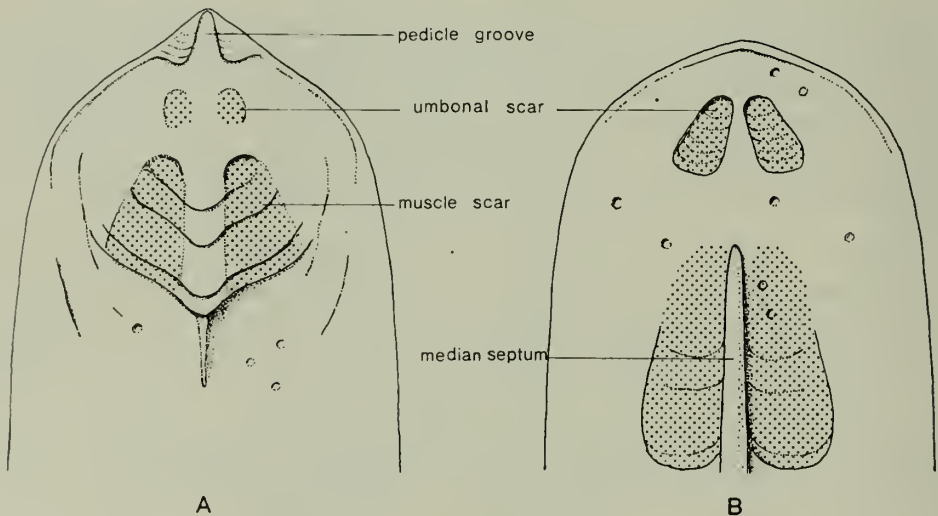


FIG. 4. Diagrammatic views of (A) the ventral and (B) the dorsal interiors of *Pseudolingula*.

3 specimens) ; muscle impressions including a pair of suboval umbonal scars situated submedially and a pair of long lateral and transmedian muscle scars inserted on either side of the median septum ; the two sets of scars extend anteriorly of the beak for 20% and 43% of the valve length respectively ; postero-medial internal surfaces of both valves sporadically and coarsely pitted.

TYPE MATERIAL.

		length	width (mm)
HOLOTYPE	Incomplete external and internal moulds of brachial valve (BB 37124)	23·0	16·0
PARATYPES	External and internal moulds of brachial valve (BB 37125a, b)	10·5	6·5
	Internal mould of pedicle valve (BB 37126)	14·0	7·6
	External and internal moulds of brachial valve (BB 37128a, b)	13·5	9·0
FIGURED SPECIMEN	Incomplete exfoliated exterior of brachial valve (BB 37129)	—	7·6

TYPE HORIZON AND LOCALITIES. Weston Beds : BB 37124 from exposures in Cwm Dingle 640 yds south of Little Weston (Grid Ref. SO 294978) ; all other specimens from outcrops 210 yds south-east of road crossing Betton Dingle, Lyde (Grid Ref. SJ 317015).

DISCUSSION. *Pseudolingula* is known to occur sporadically throughout much of the Ordovician succession of the Shelve area, but only the Weston Beds have yielded a sufficient number of specimens to allow some estimates to be made of variability in the shape and internal structure of the shell. The valves known from other horizons must also be provisionally referred to the same species as the Weston material. Indeed an internal mould of a pedicle valve (BB 37130a, b) from the Rorrington Beds exposed in Deadman's Dingle, 90 yds from the junction with Spy Wood Dingle (Grid Ref. SO 289958), affords the only clear evidence of the nature of the ventral posterior margin (Pl. 4, fig. 11), while an incomplete ventral interior (BB 37129) from the Meadowtown Beds exposed at the side of Minicop Farm (Grid Ref. SJ 314018), and a badly exfoliated valve up to 15 mm long (BB 35583) from the Mytton Flags exposed in the River Camlad (Grid Ref. SO 320919), verify the stratigraphic persistence of the characteristic ventral muscle platform and concentric ornamentation (Pl. 4, figs. 12-14).

In the absence of quantitative data on shell outline and proportions in described *Pseudolingula*, the new species can only be distinguished, for the time being, by the

TABLE 19

Statistics of length (l) and maximum depth (w) of 18 brachial valves of *Pseudolingula spatula* sp. nov. from the Weston Beds

l mm (var l)	11·84 (39·16)
\bar{w} mm (var w)	7·93 (16·775)
r	0·987
a (var a)	0·6545 (0·00067)

strong anterior development of the dorsal median septum and the strength and anterior configuration of the ventral muscle platform. In these aspects, the new species is certainly different from the type species, the mid-Caradocian *Pseudolingula quadrata* (Eichwald) from the U.S.S.R. (Goryanski 1969: 41), as well as various Caradocian American forms (Sinclair 1945: 59-62; Cooper 1956: 215-217), and other differences may become apparent in due course.

Family **ELKANIIDAE** Walcott & Schuchert 1908

MONOBOLINA Salter 1865

Monobolina plumbea (Salter)

(Pl. 5, figs. 2-10; Pl. 6, fig. 1)

1859 *Lingula plumbea* Salter in Murchison: 50, foss. 8, fig. 1.

1865 *Monobolina plumbea* (Salter) Salter in Murchison: 334, pl. xiv, fig. 10.

DIAGNOSIS. Subelliptical *Monobolina* ornamented by fila and costellae numbering about 5 and 8 per mm respectively, 5 mm antero-medially of the umbo, and with well-developed muscle fields extending anteriorly for about half the valve length.

DESCRIPTION. Subelliptical, biconvex *Monobolina* with an evenly convex brachial valve averaging 78% as long as wide and 13% as deep as long and a slightly less convex pedicle valve tending to become flattened anteriorly in adult shells; shell surface except for protogular areas ornamented by thin sharp fila and costellae in densities, 5 mm antero-medially of the umbones, of 3, 4, 5 and 6 fila per mm in 1, 2, 7 and 1 brachial valves, and of 7, 8 and 9 costellae per mm in 4, 7 and 2 brachial valves; ventral pseudointerarea roughly lamellose, orthocline, averaging 72% of the width of the valve and 11% as long as the valve medially where it is divided by a strong pedicle groove 52% as wide as long, dorsal pseudointerarea poorly developed; dorsal interior with a pair of variably impressed outside lateral and transmedial muscle scars situated submedially 44% of the valve length anterior of the dorsal umbo to form the postero-lateral boundaries to a pair of central muscle scars impressed medially at about the middle of the valve, *vascula lateralia* poorly defined; ventral muscle platform low and solid with a convex boundary culminating in a subdued median ridge extending anteriorly for 46% of the valve length; three pairs of scars representing the transmedial, middle lateral and anterior lateral muscles occurring on either side of the median ridge and flanked by a pair of anterior lateral impressions, *vascula lateralia* commonly well defined.

FIGURED MATERIAL.

	length	width (mm)
Internal mould of pedicle valve (BB 35467)	15.5	20.4
External mould of pedicle valve (BB 35468)	5.5	7.5
External and internal moulds of brachial valve (BB 35469a, b)	11.0	—
External and internal moulds of brachial valve (BB 35470a, b)	7.3	10.0
Internal mould of pedicle valve (BB 35471)	12.0	15.8
Internal mould of pedicle valve (BB 35472)	17.0	18.3
External and internal moulds of pedicle valve (BB 35473a, b)	12.5	—

HORIZON AND LOCALITIES. Mytton Flags: BB 35472 from adit entrance in Maddox's Coppice, 1200 yds ENE of St Luke's Church, Snailbeach (Grid Ref. SJ 382030); BB 35468 from sides of adit running into hillside at New Perkin's Level (Grid Ref. SJ 376022); BB 35469 from runnel just east of footpath to Blake-moorflat at head of Mytton Batch (Grid Ref. SJ 373006), BB 35470 from exposures in sunken cart track, west side of Snailbeach Coppice (Grid Ref. SJ 375026); BB 35471 from near top of steep tributary to Crowsnest Dingle 350 yds WNW of Blakemoorflat (Grid Ref. SJ 373008); BB 35467 from dump below Old Perkin's Level, Snailbeach (Grid Ref. SJ 376022); BB 35473 from dump outside adit in Perkin's Beach just below col separating Perkin's Beach and Mytton Batch (Grid Ref. SJ 366002).

DISCUSSION. The type species of *Monobolina* has been well known for over a century as an easily distinguishable inarticulate with a restricted stratigraphic and geographic range. Salter (1859: 56) based the species on specimens collected from Mytton Flags exposed west of the Stiperstones. Most of the specimens used in preparing this emended description are topotypic with his, and the remainder come from localities in the vicinity. They therefore afford an opportunity to present some reliable data on the morphologic variability of the species which illustrate the homogeneity as well as the distinctiveness of the taxon.

TABLE 20

Statistics of length (l) and maximum width (w) of 19 brachial valves of *Monobolina plumbea* (Salter)

l mm (var l)	8.82 (20.311)
\bar{w} mm (var w)	11.29 (30.383)
r	0.979
a (var a)	1.2232 (0.00362)

TABLE 21

Statistics of length (l) and thickness (th) of 18 brachial valves of *Monobolina plumbea* (Salter)

l mm (var l)	10.37 (16.106)
\bar{th} mm (var th)	1.39 (0.487)
r	0.927
$\overline{\log_e l}$ (var $\log_e l$)	2.2688 (0.1398)
$\log_e th$ (var $\log_e th$)	0.216 (0.2251)
r_e	0.934
α (var α)	1.269 (0.0128)

TABLE 22

Statistics of length (l) and length of the lateral-transmedial muscle scars (sc) of 19 brachial valves of *Monobolina plumbea* (Salter)

l mm (var l)	11.57 (9.2)
\bar{sc} mm (var sc)	5.16 (2.163)
r	0.903
a (var a)	0.4849 (0.00255)

TABLE 23

Statistics of valve length (l) and length of the entire muscle fields (ls) in 12 brachial valves of *Monobolina plumbea* (Salter)

l mm (var l)	12.89 (4.979)
$\bar{l}s$ mm (var ls)	6.69 (2.343)
\bar{r}	0.943
$\overline{\log_e l}$ (var $\log_e l$)	2.5419 (0.0296)
$\overline{\log_e ls}$ (var $\log_e ls$)	1.8754 (0.0510)
\bar{r}_e	0.943
α (var α)	1.3126 (0.0189)

TABLE 24

Statistics of length (l) and thickness (th) of 12 pedicle valves of *Monobolina plumbea* (Salter)

l mm (var l)	8.27 (17.045)
$\bar{t}h$ mm (var th)	1.0 (0.306)
\bar{r}	0.95
$\overline{\log_e l}$ (var $\log_e l$)	2.001 (0.2228)
$\overline{\log_e th}$ (var $\log_e th$)	-0.015 (0.0301)
\bar{r}_e	0.972
α (var α)	0.3676 (0.00075)

TABLE 25

Statistics of valve length (l) and muscle platform length (sc) of 13 pedicle valves of *Monobolina plumbea* (Salter)

l mm (var l)	12.74 (12.778)
$\bar{s}c$ mm (var sc)	5.88 (3.235)
\bar{r}	0.983
a (var a)	0.5032 (0.00079)

TABLE 26

Statistics of valve length (l) and pedicle groove length (pe) of 13 pedicle valves of *Monobolina plumbea* (Salter)

l mm (var l)	12.74 (12.778)
$\bar{p}e$ mm (var pe)	1.42 (0.288)
\bar{r}	0.903
a (var a)	0.1502 (0.00035)

Family **PATERULIDAE** Cooper 1956

PATERULA Barrande 1879

Paterula* cf. *bohemica Barrande

(Pl. 6, figs. 2-11)

1879 *Paterula bohemica* Barrande : plate 152.

DIAGNOSIS. Elongately oval *Paterula* with a brachial valve 87% as wide as long and 17% as deep as long; ventral beak submarginal, dorsal beak submarginal,

9% of the length of the brachial valve forward of the truncated posterior margin; limbus well developed.

DESCRIPTION. Dorsibiconvex, elongately oval *Paterula* with a slightly truncated posterior margin and a rounded anterior one, brachial valve with a mean width relative to length of 87% (range 82% to 90% for 7 valves) and a mean depth relative to length of 17% (range 15% to 20% for 5 valves), pedicle valve with a mean depth relative to length of 8% for 2 valves; surface ornamented by fine concentric lines; pedicle notch wide, immediately posterior of ventral beak; submarginal dorsal beak located, on average, 9% of the length of 3 brachial valves (range 7% to 10%) forward of their posterior margins and not constituting the greatest depth of the valve which is in mid-region.

Limbus well defined in both valves about 7% as wide as the valves are long; other internal features unknown except for two lines diverging from the ventral beak and bounding a faint median ridge.

FIGURED MATERIAL.

	length	width (mm)
Exterior of pedicle valve (BB 35590)	1.6	1.5
Exterior of brachial valve (BB 35591)	1.8	1.6
Exterior of pedicle valve (BB 35592)	1.6	1.5
Exterior of pedicle valve (BB 35593)	1.6	1.4
Exterior of brachial valve (BB 35594)	1.9	1.9
Incomplete exterior of brachial valve (BB 35595)	-	1.9
External and internal moulds of pedicle valve (BB 35588a, b)	2.0	1.9
External and internal moulds of brachial valve (BB 35589a, b)	1.6	1.4

HORIZONS AND LOCALITIES. BB 35590 to 35595 inclusive from Meadowtown Beds exposed 100 yds south-east of Minicop farm (Grid Ref. SJ 315018); BB 35588, 35589 from Hope Shales exposed in Hope Dingle behind Hope Cottage (Grid Ref. SJ 338009).

Paterula cf. *perfecta* Cooper

(Pl. 6, figs. 12, 13)

1956 *Paterula perfecta* Cooper : 258.

DIAGNOSIS. Elongately oval *Paterula* with a brachial valve 88% as wide as long and 20% as deep as long, ventral beak submarginal, dorsal beak 23% of the length of the brachial valve forward of the rounded posterior margin; limbus becoming subdued anteriorly.

DESCRIPTION. Dorsibiconvex, elongately oval *Paterula* with rounded posterior and anterior margins, brachial valve with a mean width relative to length of 88% (range 80% to 90%) and a mean depth relative to length of 20% (range 20% to 21%) for 4 valves; pedicle valve with a mean depth relative to length of 11% (range 10% to 11%) for 3 valves; surface ornamented by fine concentric lines; pedicle notch small, ventral beak submarginal, located on average 10% of the length of 3 pedicle

valves (range 9% to 11%) forward of their posterior margins ; dorsal beak representing the highest point of the brachial valve located, on average, 23% of the length of 5 brachial valves (range 15% to 25%) forward of their posterior margins.

Limbus well defined in both valves except posteriorly where it becomes obscure, other internal features unknown except for the characteristic two lines diverging from the ventral beak.

FIGURED MATERIAL.

	length	width (mm)
Exfoliated exterior of pedicle valve (BB 35596)	2.0	1.8
Exfoliated exterior of brachial valve (BB 35597)	2.0	1.8

HORIZON AND LOCALITY. Spy Wood Grit exposed in Spy Wood Dingle (Grid Ref. SO 281959).

DISCUSSION. *Paterula* occurs sporadically throughout much of the Shelve succession, although only 3 samples were available for study and even they were too small for anything but the simplest statistical assessment of variability. They do show, however, that the Shropshire *Paterula* belong to two distinct species. In the older stock, as represented by the samples from the Hope Shales and Meadowtown Beds, the posterior margin tends to be flattened or truncated, the limbus is well developed and the dorsal beak is submarginal. Such features, with the exception of the first, are also characteristic of *P. bohémica*, figured by Barrande (1879 : plate 152) from the Llanvirnian Šárka Formation of Czechoslovakia. They are not developed in specimens recovered from the Spy Wood Grit which tend to have a limbus becoming obscure anteriorly and especially a dorsal beak located well forward of a rounded posterior margin. The Spy Wood sample is close to *P. perfecta* Cooper (1956 : 258) from the Pratt Ferry Formation of Alabama except in the strength of the limbus which is continuous in the American species.

Despite these differences, the Shelve *Paterula*, provisionally at least, are most appropriately compared with *P. bohémica* and *P. perfecta*, the former to embrace specimens from the Mytton Flags to the Rorrington Beds inclusive, the latter shells occurring in the Spy Wood Grit and Aldress Shales.

Order ACROTRETIDA Kuhn 1949

Suborder ACROTRETIDINA Kuhn 1949

Superfamily ACROTRETACEA Schuchert 1893

Family ACROTRETIDAE Schuchert 1893

APSOTRETA Palmer 1955

Apsotreta sp.

(Pl. 6, figs. 14, 15)

The complementary moulds of an acrotretid pedicle valve (BB 35565a, b), from the Mytton Flags exposed near Wood House (Grid Ref. SJ 338003), are the sole

representatives of *Apsotreta* in the Shelf succession. The valve which had a subcircular commissure just under 3 mm in diameter was conical in profile and about two-fifths as deep as long with a planar apsacline pseudointerarea and an apical foramen; the mould of the pseudointerarea was not sufficiently well preserved medially to determine whether an intertrough existed. The ornamentation consisted exclusively of fine growth lines. Internally the parallel-sided apical process, so diagnostic of the genus, extended forward for about two-fifths of the length of the anterior slope between 2 pairs of simply disposed *vascula lateralia*; a pair of cardinal scars were impressed on the posterior surface.

The valve cannot be profitably compared with those of other described *Apsotreta*, but it is noteworthy that its occurrence greatly extends the stratigraphic range of the genus which had previously been regarded as restricted to the Upper Cambrian (Rowell in Williams *et al.*: H276).

CONOTRETA Walcott 1889

Conotreta stapeleyensis sp. nov.

(Pl. 6, figs. 16-21)

DIAGNOSIS. *Conotreta* with a gently convex brachial valve averaging 85% as long as wide and a conical pedicle valve 37% as deep as long with a procline pseudointerarea bearing a low deltoid arch; apical process transversely oval, submedial *vascula lateralia* not deeply divided.

DESCRIPTION. Medium-sized *Conotreta* with a very gently convex brachial valve averaging 85% as long as wide and 6% as deep as long (for 3 valves), and a conical pedicle valve averaging 37% as deep as long (for 3 valves); pseudointerarea well defined averaging 71% of the maximum width of 3 pedicle valves and procline or rarely nearly catacline in attitude, so that the beak with an apical foramen may be located forward of the posterior margin by as much as 20% of the valve length, pseudointerarea divided medially by low deltoid arch with a mean width of 30% of its length; dorsal beak small, situated at the posterior margin defined by an anacline pseudointerarea; external ornamentation consisting solely of fine growth lines.

Ventral interior with a pair of subcircular cardinal scars impressed postero-laterally of a transversely oval apical process, mantle canal system pinnate with the submedial branches of the *vascula lateralia* not deeply divided.

Dorsal interior with conspicuous propareas defined by a depressed median platform extending forward of the umbo for 18% of the length of the brachial valve and continuous with a long thin median septum of unknown profile; cardinal and anterior muscle scars forming a quadripartite pattern about the median septum and divergent *vascula lateralia* and extending anteriorly of the umbo for 56% of the valve length.

TYPE MATERIAL.

		length	width (mm)
HOLOTYPE	Internal mould of pedicle valve (BB 35566)	2.5	3.0

PARATYPES		length	width (mm)
	External mould of brachial valve (BB 35567)	3·0	3·5
	Internal mould of brachial valve (BB 35568)	3·2	3·7
	Internal mould of brachial valve (BB 35569)	2·2	2·5
	Internal mould of brachial valve with adherent shell (BB 35570)	3·2	3·5
	External and incomplete internal mould of pedicle valve (BB 35571a, b)	3·5	3·7

HORIZON AND LOCALITY. Stapeley Shales exposed on the road side north-east of bench mark 412·5, Leigh Hall (Grid Ref. SJ 334036).

DISCUSSION. A small number of acrotetid moulds recovered from the Stapeley Shales appear to constitute a new species of *Conotreta*. In the absence of precise data, no comparison can be drawn between the Stapeley *Conotreta* and other described species in respect of the shape of the shell and its principal morphological features. However, a combination of some of the basic characters of the genus immediately separate *C. stapeleyensis* from American (Cooper 1956 : 247-255), Baltic (Goryanski 1969 : 62-65) and Scottish (Williams 1962 : 90) *Conotreta*. Such features include the development of a deltoid arch in place of an intertrough dividing a predominantly procline ventral pseudointerarea, and the late division of the submedial *vascula lateralia*.

The complementary moulds of a brachial valve which is likely to belong to *Conotreta* have also been found in the Hope Shales ; but, in the absence of an associated pedicle valve, its specific affinities cannot be determined.

Superfamily **DISCINACEA** Gray 1840
 Family **TREMATIDAE** Schuchert 1893
SCHIZOCRANIA Hall & Whitfield 1875
Schizocrania salopiensis sp. nov.
 (Pl. 6, figs. 22-26)

DIAGNOSIS. *Schizocrania* with subcircular brachial valve about one-third as deep as long with posteriorly placed umbo and dichotomizing radial capillae commonly 8 to 10 per mm, 5 mm antero-medially of umbo ; large posterior adductors extending anteriorly for one-third the length of the valve.

DESCRIPTION. Brachial valve subcircular and deep being 86% as long as wide and 33% as deep as long, transverse profile evenly convex, longitudinal profile asymmetrically convex with the posteriorly placed umbo overhanging a strong groove indenting the posterior part of the valve just within the smoothly rounded posterior margin ; exterior ornamented by sporadically occurring growth lines and capillae disposed radially from the umbo, curving to intersect the posterior margin, and branching by subequal dichotomy and commonly numbering 10 per mm, 5 mm antero-medially of the umbo ; dorsal interior with thickened rounded posterior margin extending postero-laterally for over four-fifths the width of the valve.

Dorsal interior with faint median ridge ; posterior adductor scars large, suboval, slightly divergent and commonly with well-defined tracks, extending anteriorly of the posterior margin for 32% of the length of the valve ; anterior adductor scars small, suboval, normally obscure, situated about half-way along the valve and more medially placed than posterior pair ; a pair of short submedial fine ridges located forward of the anterior adductor scars may also represent muscle supports ; pedicle valve unknown.

TYPE AND FIGURED MATERIAL.

		length	width (mm)
HOLOTYPE	External and internal moulds of brachial valve (BB 35358a, b)	11.0	13.5
PARATYPES	Exterior of brachial valve (BB 35359)	9.0	10.0
	External and internal moulds of brachial valve (BB 35360a, b)	1.9	2.3
	Exterior of brachial valve (BB 35361)	3.5	3.5
	External and internal moulds of deformed brachial valve (BB 35362a, b)	7.5	6.5
	External and internal moulds of brachial valve (BB 35404a, b)	4.2	5.0

HORIZONS AND LOCALITIES. BB 35358, 35359 from Spy Wood Grit exposures 1100 yds NNE of Rorrington (Grid Ref. SJ 303015) ; BB 35360 from Rorrington Beds exposed in Deadman's Dingle 100 ft upstream from its junction with Spy Wood Brook (Grid Ref. SO 280960) ; BB 35361, BB 35362 from Rorrington Beds exposed in tributary to Lower Wood Brook, 340 yds south-east of Desert (Grid Ref. SJ 308017) ; BB 35404a, b from Betton Beds exposed in a stream 330 yds WSW of Little Weston (Grid Ref. SO 290983).

DISCUSSION. Brachial valves of *Schizocrania* occur rarely in the pre-*gracilis* rocks of the Shelve area, but are fairly common in the Rorrington Beds and Spy Wood Grit which have provided the two small samples used to derive the statistics given in Tables 27-29. Comparisons of these estimates of dorsal outline and depth and of the anterior extension of the posterior adductor scars show a significant difference ($0.05 > p > 0.02$) only in the relatively greater depth of the Spy Wood valves. This difference may reflect the growth of a consistently shallower valve during Rorrington time. Two other smaller samples from the Betton and Meadowtown Beds also differ from the Spy Wood specimens only in the depth of the brachial valve which averaged 19% and 20% of the length of 4 and 5 brachial valves respectively. However, many *Schizocrania* from the Betton, Meadowtown and Rorrington Beds show signs of collapse induced by compaction of the shaly sediments in which they occur ; and although there are no obvious signs of deformation in the specimens selected for measurement, the depressed condition of the valves which were mostly thin-shelled may yet prove to have been diagenetically induced.

Apart from the information provided in Tables 27-29, the two samples are also alike in the rounded outline of the posterior margin and in details of the dichotomizing radial ornamentation. Thus between 4 and 5 mm anterior of the umbo, 7, 8, 9, 10,

11 and 12 capillae per mm were counted respectively in 0, 1, 0, 3, 1 and 0 specimens from the Spy Wood Grit and in 1, 3, 3, 5, 1 and 1 specimens from the Rorrington Flags. The ribbing of the Betton and Meadowtown specimens shows a similar range in frequency and, although 3 valves from the Hope Shales, with counts of 10, 12 and 13 per mm, may be indicative of an older *Schizocrania* with finer radial ornamentation, the differences are not significant at present.

The Shropshire *Schizocrania* is closely related to *S. filosa* (Hall) which is known principally from the younger Trentonian rocks of N. America (Cooper 1956 : 275). No details are available on the variation in the general morphology of the American species. But the Shropshire forms are distinguishable in possessing a rounded rather than truncated posterior margin and a dorsal umbo which is not marginal : and although no pedicle valves have yet been recovered, these differences in the brachial valve seem sufficiently important to warrant the erection of a new species.

TABLE 27

Statistics of the length (l) and maximum width (w) of n brachial valves from the Spy Wood Grit (A) and the Rorrington Beds (B) of *Schizocrania salopiensis* sp. nov.

	A	B
n	6	20
l mm (var l)	6.42 (9.842)	4.29 (5.432)
w mm (var w)	7.23 (15.01)	5.1 (7.58)
r	0.997	0.986
a (var a)	1.2349 (0.00259)	1.1813 (0.0022)

TABLE 28

Statistics of the length (l) and depth (th) of n brachial valves from the Spy Wood Grit (A) and the Rorrington Beds (B) of *Schizocrania salopiensis* sp. nov.

	A	B
n	7	9
l mm (var l)	6.71 (8.822)	4.1 (3.74)
th mm (var th)	2.24 (1.233)	0.77 (0.145)
r	0.914	0.971
a (var a)	0.3739 (0.0046)	0.1969 (0.00032)

TABLE 29

Statistics of the length (l) and length of the posterior adductor scars measured from the umbo (sc) of n brachial valves from the Spy Wood Grit and the Rorrington Beds of *Schizocrania salopiensis* sp. nov.

	A	B
n	4	10
l mm (var l)	6.62 (14.23)	7.28 (12.984)
sc mm (var sc)	2.05 (1.397)	2.07 (1.193)
r	0.997	0.952
a (var a)	0.3133 (0.00033)	0.3031 (0.00107)

Family **DISCINIDAE** Gray 1840Subfamily **ORBICULOIDEINAE** Schuchert & Le Vene 1929**ORBICULOIDEA** d'Orbigny 1847***Orbiculoidea*** sp.

(Pl. 7, fig. 1)

An external mould with adherent shell of a brachial valve of *Orbiculoidea* (BB 35576) has been recovered from an unlocated exposure of Stapeley Shales. The valve which was 7 mm long and 1.2 mm deep was subcircular in outline with the beak situated about 2.5 mm forward of the slightly truncated posterior margin. The posterior sector was slightly concave, but the rest of the valve sloped evenly away from the beak to a flattened margin about 0.5 mm wide. The external surface was ornamented by fine fila; no internal features are known.

No useful purpose is served in comparing this brachial valve with those of described species, many of which are similarly proportioned. The specimen however constitutes an interesting record as one of the earliest *Orbiculoidea* so far identified.

SCHIZOTRETA Kutorga 1848***Schizotreta transversa*** sp. nov.

(Pl. 7, figs. 2, 3, 7)

DIAGNOSIS. Subcircular *Schizotreta* slightly wider than long with a ventral beak located one-third of the valve length forward of the posterior margin and a surface ornament consisting solely of growth lines.

DESCRIPTION. Subcircular *Schizotreta* with a slightly truncated posterior margin, brachial valve very gently convex, pedicle valve subconical, almost nine-tenths as long as wide and just over one-fifth as deep as long, with an even slope away from the beak except for a slightly concave posterior margin and immediately in front of the slit-like pedicle opening; dorsal beak submarginally located just over one-tenth forward of the posterior margin; surface of both valves ornamented solely by fine growth lines; interiors unknown.

TYPE MATERIAL.

		length	width (mm)
HOLOTYPE	Exfoliated pedicle valve (BB 35577)	2.7	3.1
PARATYPES	Exfoliated pedicle valve (BB 35578)	4.5	5.0
	Exfoliated brachial valve (BB 35579)	4.5	—

TYPE HORIZON AND LOCALITIES. Meadowtown Beds: BB 35577, 35578 from exposures 80 yds from Meadowtown Quarry along the Rorrington road (Grid Ref. SJ 311012). BB 35579 from exposure in lane to Kinton, 200 yds west of Holy Trinity Church, Middleton (Grid Ref. SO 295993).

DISCUSSION. There seems to be little doubt that the discinid specimens collected from the Meadowtown Beds, and also a few less well-preserved moulds from the Rorrington Beds, should be assigned to *Schizotreta* because the beak of the brachial

valve is located submarginally. In other features, however, especially the transversely oval outline and the absence of fila, the new species is unlike penecontemporaneous *Schizotreta* including the type species of the genus *S. elliptica* (Kutorga) from the Baltic area (Goryanski 1969:83), and Scottish and American stocks (Williams 1962:94-95; Cooper 1956:277-282). Only *S. microthyris* from the Oranda Formation of Virginia compares with *S. transversa* in outline although fila are finely but persistently developed on the American species and serve to distinguish the two.

Schizotreta sp.

(Pl. 7, fig. 4)

The external mould of a discinid pedicle valve (BB 35580), from the Mytton Flags exposed in the sides of the adit in the New Perkin's Level (Grid Ref. SJ 376022), has been provisionally identified as a *Schizotreta* rather than an *Orbiculoidea* mainly on the basis of its elongately oval outline and strong regular fila. The valve was 4.5 mm long and about two-thirds as wide and one-fifth as deep as long. The beak was located about one-third the length of the valve anteriorly of the curved posterior margin with the pedicle opening represented by a narrow slit, about 0.5 mm long, breaching the slightly concave posterior surface.

The valve is immediately distinguishable from *S. transversa* in its elongately oval outline and strong fila which, together with the relatively anterior location of the beak and pedicle opening, render the specimen different from most other described species. However, in view of the fact that no *Schizotreta* has previously been reported from Lower Ordovician rocks (Rowell in Williams *et al.* 1965: H285), more information, especially about the brachial valve, is required before taxonomic recognition is warranted.

Suborder CRANIIDINA Waagen 1885

Superfamily CRANIACEA Menke 1828

Family CRANIIDAE Menke 1828

PETROCRANIA Raymond 1911

Petrocrania dubia sp. nov.

(Pl. 7, figs. 5, 6, 8)

DIAGNOSIS. *Petrocrania* known only by its subquadrate, conical brachial valve with the greatest depth corresponding more or less to mid-point; elevated anterior adductor scars larger than posterior.

DESCRIPTION. Exterior of brachial valve slightly irregular, subquadrate and suboval with flattened posterior margin, 82% as long as wide (mean for 4 valves) and 26% as deep as long (mean for 3 valves) with maximum depth at about mid-point; surface with sporadic concentric growth lines, otherwise smooth; shell with thickened slightly everted margin corresponding to limb about 1 mm wide.

Interior of brachial valve with strongly impressed suboval postero-lateral adductor scars smaller than suboval elevated anterior adductor scars situated submedially up to 60% forward of the posterior margin and ornamented by fine parallel wavy ridges; mantle canal system pinnate with variably impressed sigmoidal *vascula lateralia*.

TYPE MATERIAL.

		length	width (mm)
HOLOTYPE	External and internal moulds of brachial valve (BB 35405a, b)	11.5	14.0

HORIZON AND LOCALITY. Whittery Shales: exposures in stream at north end of Spring Coppice 865 yds south-east of Hockleton Bridge (Grid Ref. SO 279997).

DISCUSSION. Although the sole craniid found in the Shelve area is represented by only 4 adult brachial valves from the Whittery Shales and a single immature brachial valve from the Aldress Shales, it is distinctive enough to be recognized as a new species. Its smooth slightly irregular external appearance suggests that it is best assigned to *Petrocrania* and the sigmoidal *vascula lateralia* impressed on the internal surface confirm this allocation. There are, however, two other internal features which are not typical of *Petrocrania*. They are the greater size of the anterior adductor scars compared with the posterior pair and the thickened margin. The new species, therefore, differs from other described *Petrocrania* in these characters. It is also distinctive in the mid-region location of the valve beak which is situated much nearer the posterior margin in American species of Ordovician age (Cooper 1956: 287-291) and in *P. inexpectata* (Barrande 1848: pl. 110, fig. V) from the Caradocian Zahořany Formation of Czechoslovakia.

Class *ARTICULATA* Huxley 1869

Order *ORTHIDA* Schuchert & Cooper 1932

Suborder *ORTHIDINA* Schuchert & Cooper 1932

Superfamily *ORTHACEA* Woodward 1852

Family *HESPERONOMIIDAE* Ulrich & Cooper 1936

HESPERONOMIA Ulrich & Cooper 1936

Hesperonomia sp.

(Pl. 7, figs. 9, 12)

The slightly deformed external and internal moulds (BB 35334a, b) of a brachial valve, collected from the Mytton Flags exposed between 50 and 55 yds down the lane from Woodside House (Grid Ref. SJ 337002), are representative of the genus *Hesperonomia* Ulrich & Cooper. The subquadrate gently concave valve was about 7 mm long and had an anacline interarea about one-seventh as long as the valve, and an open notothyrium. The ornamentation consisted of fine costellae, arising by intercalation with a density of 6 per mm, 5 mm antero-medially of the umbo, and segregated into narrow sectors by a thickening of every eighth to tenth rib. Internally a blade-like cardinal process was supported on a low notothyrial platform

bounded by short divergent brachiophores and not prolonged anteriorly into a median ridge ; simple narrow sockets were obliquely developed between the hinge-line and the brachiophores.

The combination of orthacean cardinalia, an unequally parvicostellate radial ornamentation and gently concave profile leave no doubt that the valve must be assigned to *Hesperonomia* as currently interpreted. Yet the ornamentation is so different from the normal costellate condition of the genus as to bring into question the use of the convexity or concavity of the brachial valve to distinguish between *Hesperonomiella* and *Hesperonomia*. Thus although the Mytton specimen is like *Hesperonomia australis* Ulrich & Cooper (1938 : 116) from the Odenville Limestone of Alabama, it more closely resembles the Arenigian *Hesperonomiella carmalensis* Bates (1968 : 142) from Anglesey in every respect except that the brachial valve of the Welsh species is very gently convex. Indeed, the Shropshire specimen may have been more closely related to *H. carmalensis* than to American *Hesperonomia* because the profile of the brachial valve was not as stable as its use for generic identification implies.

Family **ORTHIDAE** Woodward 1852

Subfamily **ORTHINAE** Woodward 1852

ORTHIS Dalman 1827

Orthis cf. *callactis* Dalman 1828

(Pl. 7, figs. 10, 11, 13-16)

DIAGNOSIS. Transversely semi-oval, mucronate *Orthis* with a pedicle valve over one-third as deep as long and a planar brachial valve 57% as long as wide, ornamented by about 17 costae with a wavelength of about 0.8 mm, 5 mm antero-medially of the dorsal umbo.

DESCRIPTION. Plano-convex, transversely semi-oval *Orthis* with sharply acute cardinal angles and a pedicle valve, over one-third as deep as long, evenly convex in longitudinal profile but tending to become flattened postero-laterally ; mean length of 3 brachial valves 57% (range 52% to 60%) of the maximum width, slightly convex for the first 2 mm of growth with a shallow median sulcus but becoming plane and rectimarginate in later stages of growth ; ventral interarea short, about one-twelfth as long as the pedicle valve, strongly curved, apsacline ; dorsal interarea anacline, cardinal extremities acute at about 60° ; ornamentation consisting of about 17 angular costae, about 0.8 mm in wavelength 5 mm anterior of dorsal umbo, bearing fine lamellae and capillae ; postero-lateral sectors with about 5 short rugae disposed at an acute angle with the hinge-line.

Ventral interior with teeth supported by short dental plates extending anteriorly for about one-seventh the length of the pedicle valve, pedicle callist small, muscle field with a rounded anterior boundary about one-quarter as long as the pedicle valve, adductor scar wide and not enclosed by the submedial diductor lobes.

Dorsal interior with a simple cardinal process, short divergent brachiophores, and suboval adductor scars divided by a low median ridge and extending forward for about half the length of the brachial valve.

FIGURED MATERIAL.

	length	width (mm)
External moulds of conjoined valves (BB 35497)	5.2	8.0
Incomplete external and internal moulds of pedicle valve (BB 35498a, b)	5.0	—
Incomplete external and internal moulds of brachial valve (BB 35499)	2.0	—
External moulds of conjoined valves (BB 35500)	—	5.5

HORIZON AND LOCALITIES. Mytton Flags: BB 35498 from crag in the wood of Crowsnest Dingle, 500 yds north of Blakemoorflat (Grid Ref. SJ 374012); other specimens from exposures in the adit in Maddox's Coppice, 1200 yds ENE of St Luke's Church, Snailbeach (Grid Ref. SJ 382030).

DISCUSSION. The few moulds of *Orthis* s.s. recovered from the Mytton Flags are, when allowance is made for the small size of the shells which were rarely more than 5.5 mm long, best identified as *Orthis callactis* Dalman, the type species for the genus. Illustrations of Russian representatives of the species from strata of B_{III} age (Schuchert and Cooper 1932: Pl. 2; Alichova 1953: Pl. 1) show that adult shells were more subquadrate than semi-oval and the cardinal extremities less acute than those of the Mytton specimens. But growth lines indicate that during adult development there was an acceleration of forward growth relative to lateral increment and that the outline, profile and ornamentation of young shells rendered them indistinguishable from the Shropshire specimens.

Orthis sp.

(Pl. 8, fig. 1)

A few dorsal internal moulds from the Stapeley Volcanic Group, exposed 220 yds SSE of Whitsburn Cottage, Leigh (Grid Ref. SJ 332034), are best assigned to *Orthis*. The larger (BB 35425) which is 4 mm long and about 6.5 mm wide is the mould of a very slightly convex semicircular valve with squared cardinal angles which was ornamented by about 16 rounded costae and bore a linear cardinal process on a low notothyrial platform. The brachiophores, bounding the notothyrium and defining the narrow sockets, were short, widely divergent, and disposed at about the same angle as the almost hypercline interarea.

The rounded costae, the slight convexity and the squared cardinal extremities suggest that the specimens are not assignable to *O. callactis* Dalman. But it seems advisable to withhold systematic recognition until a sample of the pedicle valves has been recovered and more is known about the variability of the brachial valve.

LENORTHIS Andreeva 1955***Lenorthis* cf. *proava*** (Salter)

(Pl. 8, figs. 2-9)

- 1866 *Orthis calligramma* var. *proava* Salter : 336.
 1868 *Orthis Carausii* [Salter ms.] Davidson : 315.
 1869 *Orthis Carausii* [Salter ms.] Davidson : 229.
 1869 *Orthis calligramma* var. *proava* Salter ; Davidson : 241.
 1883 *Orthis Carausii* Salter ; Davidson : 182-184.
 1968 *Lenorthis proava* (Salter) Bates : 146.

DIAGNOSIS. Semi-oval *Lenorthis* with a brachial valve 70% as long as wide and 17% as deep as long and a pedicle valve 31% as deep as long, ornamented by about 19 costae with a wavelength of 0.75 mm, 5 mm antero-medially of the dorsal umbo, and fine capillae ; ventral muscle scar suboval extending anteriorly for 32% the length of the pedicle valve.

DESCRIPTION. Ventribiconvex, transversely semi-oval *Lenorthis* with an evenly convex pedicle valve 31% as deep as long and a brachial valve 70% as long as wide and 17% as deep as long with a shallow sulcus extending antero-medially of the umbo for about 3 mm but becoming ill-defined thereafter ; ornamentation consisting of 15 to 20 narrowly rounded costae on 1, 1, 0, 1, 5 and 1 brachial valves more than 5 mm long, with a mean wavelength (and variance) of 0.75 mm (0.005), 5 mm anterior of the umbones of 9 brachial valves, bearing delicate capillae with those occurring medially in the interspaces tending to be stronger ; ventral interarea curved apsacline, about one-seventh as long as the pedicle valve ; dorsal interarea shorter anacline, cardinal extremities slightly acute or more rarely rectangular.

Ventral interior with strong teeth supported by narrowly divergent dental plates extending anteriorly for 17% of the length of the pedicle valve, pedicle callist small, ventral muscle field subcordate, 96% as wide as long, with the submedial diductor lobes slightly longer than the broad median adductor scar and extending anteriorly for 32% of the length of the pedicle valve ; ventral mantle canal system rarely impressed but with divergent *vascula media*.

Dorsal interior with ridge-like cardinal process, oblique sockets and short, rod-like brachiophores ; brachiophore bases extending anteriorly for about 14% of the length of the brachial valve and 49% as long as the lateral extension of the simple sockets ; dorsal adductor field quadripartite with the posterior pair of scars slightly larger, extending forward of the umbo for 56% of the length of the valve.

FIGURED MATERIAL.

	length	width (mm)
Internal and external moulds of pedicle valve (BB 35501a, b)	6.5	7.7
Internal and external moulds of pedicle valve (BB 35502a, b)	5.7	8.0
Internal and external moulds of brachial valve (BB 35503a, b)	5.3	8.0
Internal and external moulds of brachial valve (BB 35504a, b)	7.5	—

HORIZON AND LOCALITIES. Mytton Flags : BB 35501, 35502 from exposures in roots of felled tree 70 yds north of entrance to Yewtree Level, the Hollies, Snailbeach

(Grid Ref. SJ 380018) ; BB 35503, 35504 from crag in Perkin's Beach 170 yds west of Shepherd's Rock (Grid Ref. SO 372999).

DISCUSSION. The most remarkable feature of the two biconvex, costate orthids recovered from the Ordovician rocks of Shelve is that, although they belong to two different genera from widely separate horizons, they are indistinguishable in most of the attributes that are used to discriminate between species (Tables 30-38). Such dimensional estimates are numerical expressions of the way certain exoskeleton proportions were maintained during growth. They indicate the remarkable stability of the primitive strophic shell commonly referred to as 'typically orthid'. But there is no doubt that the two stocks can immediately be separated by the disposition of the ventral *vascula media* which is the chief diagnostic difference between *Orthambonites* and *Lenorthis* (Williams in Williams *et al.* 1965 : H311-313).

Lenorthis proava was first described by Salter (1866 : 336) as a variety of *Orthis calligramma* Dalman from the Arenigian Carmel Grits of Anglesey. The type specimens have since been lost, but Bates (1968 : 147) has recently collected good samples from the same horizon. Comparisons between the Mytton and Anglesey shells show them to be the same in all morphological features except the costae which are significantly coarser in *L. proava* s.s. This difference alone is not considered sufficiently important to warrant taxonomic recognition. It is, moreover, noteworthy that other penecontemporaneous forms from Europe and eastern North America may also prove to be morphologically comparable with *L. proava*. The accounts given by Rubel (1961 : 173) of '*Orthambonites*' *orbicularis* (Pander) and of '*Orthis*' *panderiana* (Hall & Clarke) by Ulrich & Cooper (1938 : 102) suggest that these stocks are *Lenorthis* closely related to the British species and especially similar in the number of costae which appears to be the most reliable character for the differentiation of species. *L. parvicrassicostatus* (Cooper) from the Upper Ordovician of Scotland (Williams 1962 : 98) is also close to *L. proava* in the shape of its shell and the number of its costae, but the external surface is not capillate.

ORTHAMBONITES Pander 1830

Orthambonites exopunctata sp. nov.

(Pl. 8, figs. 10-17 ; see also Text-fig. 3, p. 24)

DIAGNOSIS. Subcircular *Orthambonites* with the brachial valve 74% as long as wide and 18% as deep as long and a pedicle valve 31% deep as long, ornamented by about 15 costae pierced by radial rows of exopuncta, and with a wavelength of 0.8 mm, 5 mm antero-medially of the dorsal umbo ; cordate ventral muscle scar extending anteriorly for 36% of the length of the pedicle valve, dorsal adductor scars impressed for 51% of the length of the brachial valve.

DESCRIPTION. Ventribiconvex, subcircular *Orthambonites* with the pedicle valve 31% as deep as long and evenly convex in transverse and longitudinal profiles ; brachial valve 74% as long as wide and 18% as deep as long with a shallow median sulcus almost half as wide as the length of the valve but tending to die out anteriorly ; ornamentation consisting of 14 to 16 subangular costae on 2, 4 and 3 brachial valves

more than 5 mm long, with a mean wavelength (and variance) of 0.81 mm (0.005), 5 mm anterior of the umbones of 7 brachial valves, crossed by fine lamellae and perforated by a row of exopuncta on either side of each costal crest in both valves; ventral interarea curved, apsacline, about one-sixth as long as the pedicle valve; dorsal interarea anacline, shorter, cardinal extremities invariably obtuse in shells longer than 3 mm.

Ventral interior with blunt teeth rarely crenulated, supported by narrowly divergent dental plates extending anteriorly for 23% of the length of the pedicle valve, pedicle callist small, ventral muscle field cordate in adult valves 84% as wide as long with the submedial diductor lobes extending anteriorly for 36% of the length of the pedicle valve but not enclosing the shorter, medially divided, adductor scar; ventral mantle canal system saccate with proximal parts of *vascula media* adjacent.

Dorsal interior with ridge-like cardinal process, oblique sockets and short, rod-like brachiophores usually heavily encased in secondary shell, brachiophore bases extending anteriorly for 19% of the length of the brachial valve and 48% as long as the lateral extension of the simple sockets; dorsal adductor field quadripartite extending forward of the umbo for 51% of the length of the valve; dorsal mantle canal system not completely known but probably saccate.

TYPE MATERIAL.

		length	width (mm)
HOLOTYPE	Exterior of brachial valve (BB 35371)	8.5	10.2
PARATYPES	Exterior of brachial valve (BB 35372)	7.4	9.0
	Internal mould of brachial valve (BB 35373)	7.8	9.6
	Internal and external moulds of brachial valve (BB 35374a, b)	4.5	—
	Internal mould of pedicle valve (BB 35375)	8.0	8.5
	Pedicle valve and internal mould (BB 35376a, b)	8.5	9.0

HORIZON AND LOCALITIES. Whittery Shales: BB 35374 from exposures in the lower part of the west bank of the River Camlad 60 yds north-east of Marrington Farm (Grid Ref. SO 272970); BB 35375 from exposures in Whittery Quarry at the south end of Whittery Wood, near Chirbury (Grid Ref. SO 275981); all other specimens from outcrops in a stream at the north end of Spring Coppice 865 yds south-east of Hockleton Bridge, near Chirbury (Grid Ref. SO 279997).

DISCUSSION. Like *Lenorthis proava* the Whittery *Orthambonites* is characterized by a shell that did not deviate significantly during growth from the modal orthid shape and proportions, even to the development of obtuse cardinal extremities in shells only 2.5 mm long (Tables 30–38). Moreover, although the new species differs from most congeneric stocks, including the penecontemporaneous American *O. bellus* (Cooper 1956: 296) and *O. friendsvillensis* (Cooper 1956: 303), in its significantly fewer ribs, in that character and all others that can be tested statistically it is indistinguishable from the Scottish Caradocian *O. playfairi* (Reed emended Williams 1962: 97). The Whittery shells, however, are unique among all known *Orthambonites* in bearing a row of exopuncta on either side of each costa of both valves.

The exopuncta are shallow holes up to 0.2 mm deep, puncturing the external surface of the shell at acute angles directed posteriorly. Within 3 mm of the umbones of each valve, the exopuncta tend to occupy the crests of costae. In larger shells they alternate on either side of the crest line at intervals of about 0.5 mm, but become more closely crowded and approximate to a double row in the marginal zones of shells more than 7 mm long. Judging from the inferred arrangement of the mantle canals relative to the costal embayments they probably accommodated setae which dehisced at regular intervals as the shell grew forward to seal them off from the mantle edge in the manner described by Rudwick (1965 : 604) for *Acanthothiris*. If this interpretation is correct the arrangement and incidence of the exopuncta show that the growth of new setae not only balanced the loss of those isolated by shell deposition, but also compensated for the increasing expansion of the adult commissure as the decrease in forward growth tended to crowd the alternately arising setae into double rows which appeared more or less simultaneously. This pattern is different from that figured by Williams (in Williams *et al.* 1965 : H301) for *Orthambonites cf. rotundiformis* Cooper in which the morphology of the shell margin is compatible with the setal follicles having occupied narrow depressions in the intercostal eminences and not in the costal grooves. Such depressions are vestigial in *O. exopunctata*; but whether their presence is indicative of a more primitive anatomy as is suggested by their occurrence in Arenigian *Orthambonites* such as *O. calligramma* Dalman remains to be demonstrated.

TABLE 30

Statistics of length (l) and maximum width (w) of n brachial valves of *Orthambonites exopunctata* sp. nov. (A) and *Lenorthis cf. proava* (Salter) (B)

	A	B
n	17	20
l mm (var l)	4.97 (5.877)	4.8 (2.804)
\bar{w} mm (var w)	6.74 (8.36)	6.84 (3.479)
r	0.984	0.867
$\frac{r}{\log_e l}$ (var $\log_e l$)	1.497 (0.2132)	1.512 (0.1145)
$\frac{r}{\log_e w}$ (var $\log_e w$)	1.8226 (0.1695)	1.886 (0.072)
r_e	0.985	0.873
α (var α)	0.892 (0.0016)	0.793 (0.00829)

TABLE 31

Statistics of length (l) and depth (th) of n brachial valves of *Orthambonites exopunctata* sp. nov. (A) and *Lenorthis cf. proava* (Salter) (B)

	A	B
n	13	8
l mm (var l)	6.55 (5.389)	5.84 (1.569)
th mm (var th)	1.18 (0.271)	0.99 (0.059)
r	0.863	0.617
a (var a)	0.224 (0.00117)	0.193 (0.0038)

TABLE 32

Statistics of length (l) and depth (th) of n pedicle valves of *Orthambonites exopunctata* sp. nov. (A) and *Lenorthis* cf. *proava* (Salter) (B)

	A	B
n	24	17
l mm (var l)	7.4 (5.892)	5.51 (3.441)
th mm (var th)	2.31 (0.674)	1.72 (0.2106)
r	0.919	0.578
a (var a)	0.338 (0.0008)	0.247 (0.00272)

TABLE 33

Statistics of length of pedicle valve (l) and length of ventral muscle scar (sc) for n specimens of *Orthambonites exopunctata* sp. nov. (A) and *Lenorthis* cf. *proava* (Salter) (B)

	A	B
n	22	16
l mm (var l)	7.79 (5.934)	5.71 (2.133)
sc mm (var sc)	2.77 (0.942)	1.81 (0.343)
r	0.939	0.906
a (var a)	0.399 (0.00094)	0.401 (0.00205)

TABLE 34

Statistics of length (l) and maximum width (w) of the ventral muscle scar of n specimens of *Orthambonites exopunctata* sp. nov. (A) and of *Lenorthis* cf. *proava* (Salter) (B)

	A	B
n	18	14
l mm (var l)	2.81 (0.789)	1.78 (0.299)
w mm (var w)	2.36 (0.426)	1.7 (0.174)
r	0.912	0.895
a (var a)	0.735 (0.00569)	0.763 (0.00966)

TABLE 35

Statistics of length of pedicle valve (l) and length of dental plates (dl) for n specimens of *Orthambonites exopunctata* sp. nov. (A) and of *Lenorthis* cf. *proava* (Salter) (B)

	A	B
n	21	16
l mm (var l)	7.23 (6.153)	5.75 (2.172)
dl mm (var dl)	1.68 (0.357)	0.98 (0.137)
r	0.923	0.895
$\frac{\log_e l}{l}$ (var $\log_e l$)	1.996 (0.098)	1.717 (0.0636)
$\frac{\log_e dl}{dl}$ (var $\log_e dl$)	0.46 (0.1188)	-0.66 (0.1334)
r _e	0.926	0.903
α (var α)	1.101 (0.0091)	1.448 (0.0275)

TABLE 36

Statistics of length of brachial valve (l) and length of brachiophores at their bases (c) for n specimens of *Orthambonites exopunctata* sp. nov. (A) and of *Lenorthis* cf. *proava* (Salter) (B)

	A	B
n	8	13
l mm (var l)	6.16 (4.389)	5.6 (1.833)
c̄ mm (var c)	1.19 (0.167)	0.8 (0.032)
r	0.971	0.729
a (var a)	0.195 (0.00036)	0.132 (0.00074)

TABLE 37

Statistics of length of brachiophores at their bases (l) and distances between the lateral edges of sockets (w) for n brachial valves of *Orthambonites exopunctata* sp. nov. (A) and *Lenorthis* cf. *proava* (Salter) (B)

	A	B
n	6	12
l mm (var l)	1.03 (0.111)	0.81 (0.034)
w̄ mm (var w)	2.15 (0.347)	1.67 (0.09)
r	0.944	0.727
a (var a)	1.771 (0.0848)	1.637 (0.1262)

TABLE 38

Statistics of length of brachial valve (l) and length of adductor scar from umbo (sc) of n specimens of *Orthambonites exopunctata* sp. nov. (A) and of *Lenorthis* cf. *proava* (Salter) (B)

	A	B
n	8	7
l mm (var l)	6.16 (4.389)	5.46 (2.913)
sc̄ mm (var sc)	3.13 (0.899)	3.06 (0.767)
r	0.967	0.948
a (var a)	0.453 (0.00221)	0.513 (0.0054)

Subfamily **PRODUCTORTHINAE** Schuchert & Cooper 1931

NICOLELLA Reed 1917

Nicolella cf. *actoniae* (J. de C. Sowerby)

(Pl. 9, figs. 1-6)

1839 *Orthis actoniae* J. de C. Sowerby in Murchison : 639.

1963 *Nicolella actoniae* (Sowerby) Williams : 352.

DIAGNOSIS. Plano-convex, mucronate *Nicolella* with a pedicle valve 32% as deep as long and a brachial valve 64% as long as wide, ornamented by 12 to 15 angular costae with a wavelength of about 1.1 mm, 5 mm antero-medially of the dorsal umbo ; costellae rare with 3 \bar{a} arising first, cordate ventral muscle scar extending anteriorly for 34% of the length of the pedicle valve, dorsal adductor scars impressed for 48% of the length of the brachial valve.

DESCRIPTION. Plano- to slightly concavo-convex, subquadrate *Nicolella* with cardinal angles almost invariably acute in all growth stages, pedicle valve evenly convex 32% as deep as long and a brachial valve 64% as long as wide; ornamentation consisting of 12 to 15 angular costae in 2, 1, 2 and 2 brachial valves more than 8.5 mm long with a mean wavelength (with variance) of 1.09 mm (0.008) at 5 mm antero-medially of the umbones of 10 brachial valves, rarely branching in shells longer than 7.5 mm with 3 \bar{a} usually arising first, concentric lamellae strong and continuous but not occurring regularly; ventral interarea short, curved orthocline; dorsal interarea very short, curved anacline.

Ventral interior with small blunt teeth supported by widely divergent dental plates extending anteriorly for 16% of the length of the pedicle valve, pedicle callist small, ventral muscle field cordate, slightly wider than long in adult valves with the submedial diductor lobes extending anteriorly for 34% of the length of the pedicle valve but not enclosing the shorter, undifferentiated median adductor scar.

Dorsal interior with ridge-like erect cardinal process, chilidial plates present, sockets slot-like defined by brachiophores extending laterally parallel to the hinge-line for a distance equivalent to about one-third of the length of the brachial valve; dorsal adductor scars generally obscure but quadripartite with the larger anterior pair extending forward of the dorsal umbo for 48% of the length of 3 valves (range 46% to 50%).

FIGURED MATERIAL.

	length	width (mm)
External and internal moulds of brachial valve (BB 35327a, b)	3.0	5.5
External and internal moulds of brachial valve (BB 35328a, b)	10.0	15.0
External mould of brachial valve (BB 35329)	13.0	18.0
Incomplete internal mould of pedicle valve (BB 35330)	—	—
Internal mould of pedicle valve (BB 35331)	12.0	15.0

HORIZON AND LOCALITIES. Whittery Shales: BB 35327 from Whittery Quarry at south end of Whittery Wood near Chirbury (Grid Ref. SO 275981); BB 35328 from outcrops in west bank of the River Camlad 60 yds north-east of Marrington Farm (Grid Ref. SO 272970); BB 35329, 35331 from outcrops half way down the path going south from Marrington Farm to the valley bottom (Grid Ref. SO 272967); BB 35330 from outcrops in stream at north end of Spring Coppice 865 yds south-east of Hockleton Bridge (Grid Ref. SO 279997).

DISCUSSION. With the identification of the Whittery *Nicolella* as a form which is indistinguishable from the Actonian *N. actoniae* (J. de C. Sowerby), the remarkable morphological stability of that species becomes apparent, for it extends throughout the Upper Caradocian and Lower Ashgillian without significant change in any of its definable features (Williams 1963: 352-356, Wright 1964: 165-167). Tables 39-42 give the statistics for the main external and internal features of the Whittery specimens, and their comparison with similar data for *N. actoniae* from the Acton Scott Beds and the Portrane Limestone, and for *N. actoniae obesa* Williams from the Gelli-grin Calcareous Ashes, shows no significant difference in any of the listed characters. It is noteworthy that even in respect of the relative depth of the pedicle

TABLE 39

Statistics of length (l) and maximum width (w) of 9 brachial valves of *Nicolella* cf. *actoniae* (Sowerby)

l mm (var l)	7.93 (12.915)
\bar{w} mm (var w)	12.37 (26.845)
r	0.978
a (var a)	1.4417 (0.0128)

TABLE 40

Statistics of length (l) and maximum depth (th) of 15 pedicle valves of *Nicolella* cf. *actoniae* (Sowerby)

l mm (var l)	11.53 (12.595)
th mm (var th)	3.66 (1.41)
r	0.854
a (var a)	0.3346 (0.00234)

TABLE 41

Statistics of length of pedicle valve (l) and length of ventral muscle scar (sc) for 12 specimens of *Nicolella* cf. *actoniae* (Sowerby)

l mm (var l)	12.79 (3.019)
\bar{sc} mm (var sc)	4.29 (0.481)
r	0.802
a (var a)	0.3991 (0.00568)

TABLE 42

Statistics of length of pedicle valve (l) and anterior extension of dental plates (dl) of 7 specimens of *Nicolella* cf. *actoniae* (Sowerby)

l mm (var l)	11.73 (6.778)
\bar{dl} mm (var dl)	1.91 (0.332)
r	0.964
a (var a)	0.2212 (0.0007)

valve the Whittery sample is intermediate between *N. actoniae* and the significantly deeper Bala subspecies and, when allowance is made for the variability of the samples, comparable with both in the inherent profile and rate of deepening of the pedicle valve.

The development of the ribbing does, however, indicate the much closer affinity with *N. actoniae* than with the Welsh subspecies. In the number and wavelength of costae the Whittery sample is like both *N. actoniae* and its subspecies. However, in all 8 brachial valves between 8.5 and 14.2 mm long, no costellae arise within 7.5 mm of the umbo and only 3 out of 8 valves show any branching, which consists solely of the appearance of 3 \bar{a} in two specimens and 4 \bar{a} arising before 3 \bar{a} in the third. The Whittery sample is therefore more like *N. actoniae* in the rare development of costellae within the size range stipulated above, and also in being less thick-shelled than the Bala subspecies at such stages in growth (Williams 1963 : 356).

Only a few other remarks can be made about the Whittery shells. As in other *Nicolella*, muscle impressions are generally poorly defined. The ventral muscle field was wider than long in young shells, but during growth there was an acceleration in the anterior extension of the submedial diductor lobes so that the muscle field of adult pedicle valves tended to be longer than wide; and the mean percentage width relative to length from the umbo (with variance) of 6 muscle impressions between 3.0 and 5.5 mm long was 109.4% (425.84).

Subfamily WHITTARDIINAE nov.

DIAGNOSIS. Plano- to concavo-convex orthids with a catacline to procline ventral interarea, disharmonic costellate ornamentation and open delthyrium and notothyrium; ventral muscle field strongly bilobed with short parallel dental plates and three or four pairs of short ridges radiating from the muscle field boundary; cardinalia consisting of a simple cardinal process and widely divergent brachiophores ankylosed to the hinge line, adductor scars subtriangular, divided into inner and outer pairs by *vascula myaria*; ventral mantle canal system saccate, dorsal lemniscate to pinnate.

DISCUSSION. The new genus *Whittardia* represents an unexpected find within such well-known Ordovician successions as those of Shropshire, because although it is undoubtedly orthacean in its general organization and more particularly orthid in the bilobed nature of the ventral muscle field and the simplicity of the cardinalia, it is sufficiently unusual in a number of features to have aroused the attention of palaeontologists had it been discovered earlier. Among such features, the disharmonic ornamentation of the valves in the earlier stages of growth is the most bizarre. Judged on the umbonal region of adult moulds, dorsal valves, up to about 5 mm long, were convex and sulcate and ornamented by three symmetrically disposed pairs of strong costae radiating from the umbo. The only other ornamentation developed within 2 mm of the umbo, in all valves examined, consisted of fine closely-spaced lamellae. Thereafter at variable distances from the umbo intercalated costellae appeared, normally with a few thickened differentially. But with the relative loss in strength of the primary costellae in valves longer than 5 mm, the pattern became more evenly multicostellate with the costae arising by dichotomy or intercalation and interrupted by fine concentric lamellae which were especially conspicuous in the postero-lateral sectors free of ribs. The umbonal surface of the pedicle valve, on the other hand, appears at first sight to have been quite different, although details are usually obscured by the presence of a large mesothyridid foramen and the irregularity of the surface. The first-formed part of the preserved external mould, for about 2 mm anterior of the foraminal edge, appears to be flat and smooth and although valves up to about 5 mm long were sufficiently carinate to accommodate the dorsal sulcus they were evenly and closely costellate and without sign of accentuated interspaces corresponding to the strong costae of the brachial valve. In the ventral interior, however, there were three or four pairs of low narrow ridges radiating from the boundaries of the ventral muscle field and dying

out peripherally, which could well have been complementary to the accentuated costae of the brachial valve. This arrangement suggests that the valves were imperfectly matched along the commissure, and such a loose fit is compatible with the weak articulation indicated by the simplicity of the teeth, the shallowness of the sockets, and the powerful development of the adductor musculature as inferred from the wide ventral impression and the deep posterior insertion of the dorsal attachment areas.

The other unusual features of the new genus are the catacline to procline ventral interarea and the profile of the brachial valve. The disposition of the ventral interarea was not unique among orthaceans but it was associated with a large mesothyridid foramen which must have accommodated a thick pedicle that was so short as to bring the pedicle valve into contact with the substratum; the irregular contours of the valve are not *post mortem* features but expressions of growth in a physically restrictive environment. The longitudinal profile of the brachial valve was initially convex, but beyond the 2 mm growth stage the valve became gently concave. This attitude, however, was accentuated or reversed along a few narrow arcs resembling concentric rugae or, if incomplete, incipient geniculation. Such bands corresponded to only vague concentric indentations in the ventral interior, again indicative of the degree to which the valves grew independently of each other at the edges.

No other described orthacean compares closely with *Whittardia*: indeed the principal difficulty is deciding the suprageneric group to which it is best assigned. There is a superficial resemblance to the dinorthid *Plesiomya* (*Retrosistria*) in the ventral muscle impression but this is due to the catacline attitude of the ventral interarea in both stocks. Yet the simplicity of the cardinalia, and the bilobed nature of the ventral muscle scar and the mantle canal systems, suggest that the ancestor of *Whittardia* was more likely to have been an orthid and, provisionally at least, a monotypic subfamily of the Orthidae has been created to accommodate the new genus.

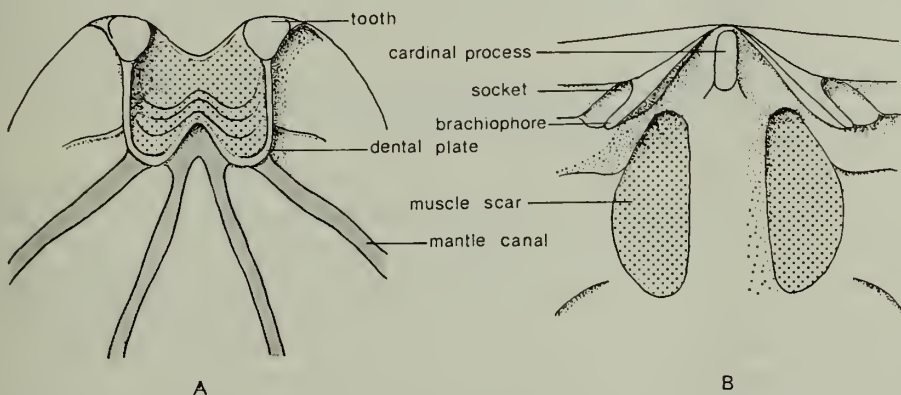


FIG. 5. Diagrammatic views of (A) the ventral and (B) the dorsal interiors of *Whittardia*.

Genus *WHITTARDIA* nov.

NAME. In honour of the late Professor W. F. Whittard.

DIAGNOSIS. Subquadrate to semi-elliptical, sulcate shell with an irregularly convex, carinate pedicle valve and a brachial valve initially convex but becoming concave in adult stages of growth; radial ornamentation of both valves costellate, interrupted by fine lamellae, but with the finely lamellose umbonal region of the brachial valve bearing only 6 symmetrically disposed accentuated costae becoming subdued anteriorly; ventral interarea gently curved catacline to procline, with wide open delthyrium and mesothyridid foramen, dorsal interarea very short, anacline, notothyrium open; shell probably impunctate.

Ventral interior with widely divergent tooth ridges and flat, oblique teeth supported by short receding subparallel, widely spaced dental plates, postero-laterally enclosing a bilobed muscle field with a relatively short undifferentiated adductor scar separating divergent submedial diductor lobes which encroach onto a pair of divergent *vascula media*; ventral mantle canal system probably saccate with *vascula media* branching early; 3 or 4 pairs of narrow, low ridges radiate from the boundary of the muscle field and die away peripherally.

Dorsal interior with simple cardinal process elevated above a shallow notothyrial platform and wide short median ridge; brachiophores short, widely divergent, ridge-like, scarcely elevated above hinge-line and postero-laterally defining a pair of elliptical sockets; adductor scars subtriangular with posterior apices deeply inserted in the notothyrial platform and divided into outer and inner sets by obliquely disposed *vascula myaria*; dorsal mantle canal pattern lemniscate or pinnate.

TYPE SPECIES. *Whittardia paradoxica* sp. nov. from the Whittery Shales, Shropshire.

Whittardia paradoxica sp. nov.

(Pl. 9, figs. 7-15; Pl. 10, figs. 1, 2, 4; Text-fig. 5)

DIAGNOSIS. Concavo-convex, subquadrate sulcate *Whittardia* with a pedicle valve 34% as deep as long and a brachial valve 79% as long as wide, ornamented by multicostellae with counts of 3 or 4 ribs per mm, 5 mm antero-medially of the dorsal umbo; ventral and dorsal muscle scars extending anteriorly for 24% and 46% of their respective valve lengths.

DESCRIPTION. Variably subquadrate, sulcate *Whittardia* with a convex medially carinate pedicle valve with a mean length relative to width of 66% (range 56% to 83%) and a mean depth relative to length of 34% (range 26% to 41%) for 4 valves, and an irregularly concave brachial valve averaging 79% as long as wide (range 71% to 84%) for 4 valves; radial ornamentation becoming multicostellate by intercalation and dichotomy in adult shells with 3 and 4 ribs per mm, 5 mm antero-medially of the umbones of 2 brachial valves in each case.

Ventral interior with bilobed ventral muscle scar becoming longer than wide in adult shells and extending forwards for an average of 24% of the length of 4 pedicle valves (range 20% to 33%).

Dorsal interior with cardinalia consisting of a simple cardinal process and widely divergent brachiophores extending forwards for an average of 17% (range 14% to 19%) of the length of 4 pedicle valves and supported by a shallow notothyrial platform; dorsal adductor scars subtriangular, deeply impressed posteriorly on either side of a short low median ridge, and extending forwards for 46% (range 42% to 51%) of the length of 4 brachial valves.

TYPE MATERIAL.

		length	width (mm)
HOLOTYPE	Internal and external moulds of brachial valve (BB 35381a, b)	6.5	7.5
PARATYPES	Internal and external moulds of pedicle valve (BB 35382a, b)	11.5	14.0
	Internal and external moulds of pedicle valve (BB 35383a, b)	7.5	—
	Internal and external moulds of brachial valve (BB 35384a, b)	8.0	—
	Internal mould of brachial valve (BB 35385)	7.2	—
	Internal mould of pedicle valve (BB 35386)	7.5	—
	External and internal moulds of brachial valve (BB 35402a, b)	7.0	—
	External and internal moulds of pedicle valve (BB 35403a, b)	7.0	—

HORIZON AND LOCALITIES. Whittery Shales: BB 35384 from outcrops in stream at north end of Spring Coppice, 865 yds south-east of Hockleton Bridge (Grid Ref. SO 279997); all other specimens from Whittery Quarry at the south end of Whittery Wood, near Chirbury (Grid Ref. SO 275981).

DISCUSSION. The sample of *Whittardia paradoxica* available for assessing the morphological variation within the species was too small to estimate proportional growth, but statistics incorporated in the description were calculated for valves between 3 and 12.4 mm in length and give some idea of the variability.

Family **DOLERORTHIDAE** Öpik 1934
 Subfamily **DOLERORTHINAE** Öpik 1934
DOLERORTSIS Schuchert & Cooper 1931
Dolerorthis cf. *tenuicostata* Williams

(Pl. 10, figs. 3, 5, 7, 10, 13)

1955 *Dolerorthis tenuicostata* Williams in Whittington & Williams: 406.

The incomplete external and internal moulds of a brachial and pedicle valve (BB 35459a, b; BB 35460a, b) of *Dolerorthis* have been collected from the Whittery Shales exposed in Whittery Quarry in the south end of Whittery Wood, near Chirbury (Grid Ref. SO 275981). The shell was ventri-biconvex with a pedicle valve about one-fifth as deep as long, sloping evenly away from the beak, and a very

gently convex, transversely semi-oval brachial valve just over two-thirds as long as broad and lacking a sulcus. The ventral interarea was strongly apsacline and, at one-eighth the length of the pedicle valve, longer than the anacline dorsal interarea; both delthyrium and notothyrium were open. The ornamentation consisted of microscopic concentric lamellae superimposed on fine costellae numbering 4 and 5 per mm at 5 mm antero-medially of the umbones, with costellae, mainly branching internally, arising early so that about 60 occur at the 5 mm growth stage and 75 at the margin of the brachial valve 8.5 mm long.

A pair of dental plates extending forward for about one-seventh the length of the pedicle valve defined the umbonal cavity which was occupied by a subtriangular muscle field with a relatively broad median adductor track; only proximal traces of the *vascula media*, separated by a short median ridge, are preserved.

The cardinalia consisted of a narrow ridge-like cardinal process and sharp, divergent, unsupported brachiophores extending forward for one-fifth of the length of the brachial valve; only faint impressions of a pair of suboval adductor scars are preserved on either side of a low median ridge becoming indistinct anteriorly.

The fineness of the ribbing as well as the internal features indicate that the Whittery *Dolerorthis* resembles *D. tenuicostata* (Williams 1955: 406) from the Derfel Limestone of N. Wales. There are, however, some differences especially in the lesser convexity of the brachial valve of the Whittery species which also lacks a sulcus. These differences may ultimately prove to be taxonomically important.

Subfamily **GLYPTORTHINAE** Schuchert & Cooper 1931

GLYPTORTHIS Foerste 1914

Glyptorthis viriosa sp. nov.

(Pl. 10, figs. 6, 8, 9, 11, 12, 14, 15; Pl. 11, figs. 1, 2, 4)

DIAGNOSIS. Small *Glyptorthis* with a shallowly sulcate brachial valve about four-fifths as long as wide and a catacline pedicle valve 37% as deep as long, ornamented by fascicostellae numbering 2 or 3 per mm, 5 mm antero-medially of the dorsal umbo, and concentric lamellae with a modal density of 3 per mm between 5 and 6 mm antero-medially of the dorsal umbo.

DESCRIPTION. Subcircular, ventribiconvex *Glyptorthis* with roundly obtuse cardinal angles; pedicle valve sharply carinate and 37% as deep as long, brachial valve 80% as long as wide and 23% as deep as long with a persistent rounded median sulcus, up to half as wide as the valve length, flanked by evenly convex lateral areas; ventral interarea catacline to slightly apsacline, about one-third as long as the valve, with narrow delthyrium with subparallel boundaries; dorsal interarea anacline with an open notothyrium; radial ornamentation fascicostellate with ribs branching almost exclusively internally in the first four sectors and numbering 2 and 3 per mm, 5 mm antero-medially of the umbones of 3 brachial valves in each case; concentric ornamentation consisting of strongly developed lamellae with counts of 3 and 4 in 3 and 1 valves between 5 and 6 mm antero-medially of the umbones.

Small trigonal teeth supported by narrowly divergent dental plates extending forward for 20% of the length of the pedicle valve; ventral muscle scar normally elongately pentagonal, with relatively wide median adductor scars flanked by somewhat shorter diductor scars, wider than long in young valves but becoming much more elongate in adult shells with a mean width of 97% of the length and extending anteriorly for 38% of the length of the valve.

Cardinal process simple and blade-like, brachiophores divergent and pointed with the secondary shell, forming the boundaries of the denticulate sockets and notothyrium, elevated above the brachial valve floor to simulate fulcral plates; convergent brachiophore bases extending forward for 19% of the valve length and 48% as long as wide; adductor muscle field quadripartite with a pair of suboval scars impressed on either side of the median ridge and extending anteriorly of the umbo for 52% of the length of the valve.

TYPE MATERIAL.

		length	width (mm)
HOLOTYPE	External and internal moulds of brachial valve (BB 35505a, b)	4.7	6.0
PARATYPES	External and internal moulds of pedicle valve (BB 35506a, b)	4.5	5.5
	Internal mould of pedicle valve (BB 35507)	5.0	6.5
	Internal and incomplete external moulds of brachial valve (BB 35508a, b)	5.5	7.5
	Internal mould of pedicle valve (BB 35509)	6.5	7.0

TYPE HORIZON AND LOCALITY. All specimens from exposures of Spy Wood Grit, 1100 yds NNE of Rorrington (Grid Ref. SJ 303015).

DISCUSSION. Remains of *Glyptorthis* have been recovered from the Meadowtown Beds, Whittery Shales and Spy Wood Grit, but are common only in the last-named formation which has furnished the sample used in establishing a new species most closely related to *G. nantensis* McGregor (1961: 187) from the Upper Llandeilo of the Berwyn Hills. However, even in the absence of precise information about the variability of the Welsh species, its pedicle valve is obviously not only much deeper but is further characterized by an interarea which is 'slightly apsacline, almost orthocline', and a significantly larger muscle scar.

Other penecontemporaneous Ordovician species from Ireland, Scotland and N. America also differ greatly. According to data kindly provided by Mrs H. Carlisle, in the brachial valve of *G. crispa* M'Coy from the Tramore Limestone of Ireland the cardinalia were relatively wider while the ventral muscle scar extended anteriorly more slowly during growth than in the Shropshire species. *G. balclatchiensis* (Davidson) from the Ardmillan Series of Scotland (Williams 1962: 109), and *G. assimilis* Cooper (1956: 361) from the Lower Ridley of Tennessee, both differ in being significantly wider. The former species also differs in the replacement of the dorsal sulcus by a narrow rounded fold during adult stages of growth, and the latter in being more coarsely imbricate.

Specimens of *Glyptorthis* recovered from the Whittery Shales and Meadowtown Beds may, provisionally at least, be referred to the new species despite minor differences in morphology.

The few moulds known from the younger formation include only one external mould of a brachial valve large enough to provide data about ornamentation. Counts of 2 per mm at 5 mm antero-medially of the umbo were obtained for both radial and concentric ornamentation and are smaller than those for *G. viriosa* s.s. In all other features, however, the shells must have been indistinguishable from the Spy Wood forms and more information is necessary to establish the significance of the difference.

The more frequently occurring *Glyptorthis* from the Meadowtown Beds, on the other hand, is identical with the new species except for the size of the cardinalia which extend anteriorly for only 10% of the length of the two known brachial valves. This size relationship is subnormal for brachial valves of comparable length in the Spy Wood sample, although more specimens are needed to assess the significance of the difference. Two specimens are figured (Pl. 10, fig. 15; Pl. 11, figs. 1, 2, 4): a brachial valve (BB 35520a, b) from loose flags by the side of Minicop Farm (Grid Ref. SJ 314018), and a pedicle valve (BB 35521a, b) from Quinton's Quarry in the field 200 yds north-east of Meadowtown Chapel (Grid Ref. SJ 312013).

TABLE 43

Statistics of length (l) and maximum width (w) of 17 brachial valves of *Glyptorthis viriosa* sp. nov.

l mm (var l)	4.23 (3.037)
\bar{w} mm (var w)	5.26 (3.424)
r	0.978
$\frac{\log_e l}{\log_e w}$ (var $\log_e l$)	1.3637 (0.1567)
$\log_e w$ (var $\log_e w$)	1.6029 (0.1165)
r_e	0.981
α (var α)	0.8621 (0.00191)

TABLE 44

Statistics of length (l) and maximum depth (th) of 19 brachial valves of *Glyptorthis viriosa* sp. nov.

l mm (var l)	4.28 (3.05)
\bar{th} mm (var th)	0.97 (0.162)
r	0.866
a (var a)	0.2306 (0.00078)

TABLE 45

Statistics of length (l) and maximum depth (th) of 23 pedicle valves of *Glyptorthis viriosa* sp. nov.

l mm (var l)	3.46 (4.857)
\bar{th} mm (var th)	1.27 (0.594)
r	0.945
a (var a)	0.3497 (0.00061)

TABLE 46

Statistics of length (l) and length of dental plates (dl) in 20 pedicle valves of *Glyptorthis viriosa* sp. nov.

l mm (var l)	3.94 (4.674)
dl mm (var dl)	0.81 (0.246)
r	0.952
a (var a)	0.2293 (0.00027)

TABLE 47

Statistics of length (l) and length of ventral muscle scar (sc) in 22 pedicle valves of *Glyptorthis viriosa* sp. nov.

l mm (var l)	3.94 (4.848)
sc mm (var sc)	1.49 (1.124)
r	0.989
$\frac{\log_e l}{l}$ (var $\log_e l$)	1.237 (0.2711)
$\log_e sc$ (var $\log_e sc$)	0.1948 (0.4092)
r_e	0.994
α (var α)	1.2285 (0.00095)

TABLE 48

Statistics of length (l) and width (w) of the ventral muscle scar in 23 pedicle valves of *Glyptorthis viriosa* sp. nov.

l mm (var l)	1.46 (1.088)
w mm (var w)	1.42 (0.282)
r	0.932
$\frac{\log_e l}{l}$ (var $\log_e l$)	0.1772 (0.4098)
$\log_e w$ (var $\log_e w$)	0.2866 (0.1305)
r_e	0.957
α (var α)	0.5642 (0.00126)

TABLE 49

Statistics of length (l) and length of brachiophore bases (lc) in 19 brachial valves of *Glyptorthis viriosa* sp. nov.

l mm (var l)	4.62 (2.227)
lc mm (var lc)	0.86 (0.084)
r	0.865
a (var a)	0.1938 (0.00055)

TABLE 50

Statistics of length (l) and maximum lateral extension (w) of the brachiophore bases in 18 brachial valves of *Glyptorthis viriosa* sp. nov.

l mm (var l)	0.86 (0.088)
w mm (var w)	1.78 (0.274)
r	0.842
a (var a)	1.762 (0.05665)

Family **ALIMBELLIDAE** Andreeva 1960 emended A. W.

DIAGNOSIS. Biconvex, smooth to capillate, uniplicate orthaceans with well-developed curved interareas and open delthyrium and notothyrium; ventral muscle field impressed on pseudospondylium, dental plates absent at least in adult shells; blade-like cardinal process and strong brachiophores supported by variably developed notothyrial platform; ventral mantle canal pattern saccate, dorsal digitate.

DISCUSSION. This family was erected by Andreeva (1960: 292) to include two Tremadocian genera from the Urals, *Alimbella* Andreeva 1960 and *Medesia* Andreeva 1960 which were considered by her to be aberrant porambonitaceans, a conclusion accepted by Biernat (in Williams *et al.* 1965: H530), in her review of the Syntrophiidina for the *Treatise on Invertebrate Paleontology*. In her discussion of the affinities of the Russian genera, Andreeva conceded that the morphology of the brachial valves is typically 'orthoid, similar to *Platystrophia*' (1960: 292) but believed the organization of the pedicle valve to be so decisively porambonitacean as to preclude any connection with the orthaceans. It is difficult to understand how Andreeva came to this conclusion unless she had attached an overriding importance to the uniplicate condition of the shell which is certainly much more characteristic of the porambonitaceans than the orthaceans. Yet, if the ventral sulcus is ignored, the pedicle valves of both genera are immediately seen to be unexceptionally orthacean in the strong development of the interareas, the arrangement of the ventral muscle fields, and above all in the saccate mantle canal systems, with the proximal parts of the *vascula media* disposed medially in a manner which is unknown among the digitate porambonitaceans. The pseudospondylium is admittedly a rare feature among orthaceans but is known to have developed independently in several articulate groups and is, in any event, as well defined in the orthid *Glossorthis* as it is among the alimbellids.

All other features displayed by the Russian genera, such as the cardinal process and lack of brachiophore supports, are much more, but not exclusively, characteristic of the orthaceans rather than the porambonitaceans. It therefore seems reasonable to transfer the family to the Orthacea and to regard the stocks assigned to it as bearing the same relationship to the Orthidae as the Platystrophiinae do to the Plectorthidae and Finkelnburgiidae.

ASTRABORTHIS gen. nov.

NAME. An orthacean shaped like a saddle (Gk. ἀστράβη).

DIAGNOSIS. Subcircular, biconvex, uniplicate shells with a deeply sulcate pedicle valve ornamented by coarse angular costellae; ventral interarea curved apsacline with wide, open delthyrium; dorsal interarea curved anacline with wide, open notothyrium; shell probably impunctate.

Ventral interior with simple rounded teeth ankylosed to a pseudospondylium by solid deposits of secondary shell in adult valves, which may mask short receding dental plates, pedicle callist absent; broad, medially divided adductor scars and

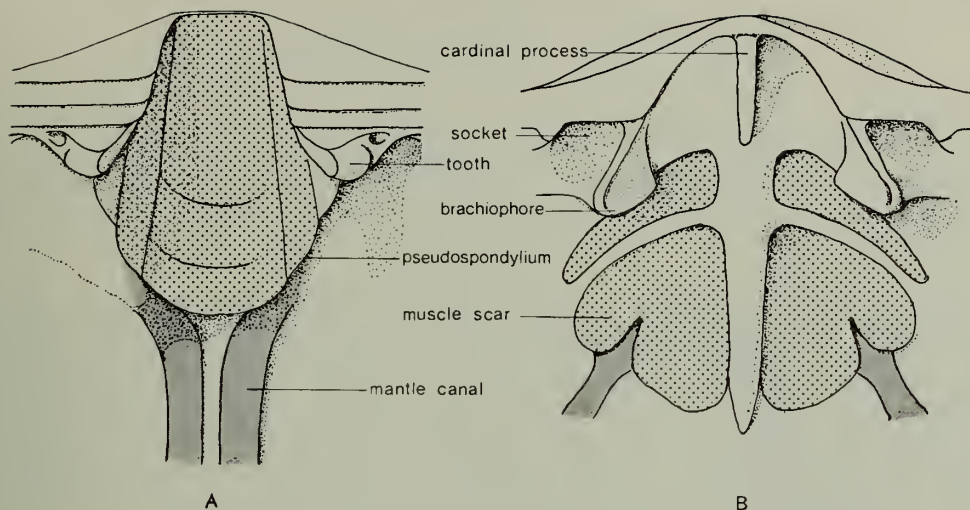


FIG. 6. Diagrammatic views of (A) the ventral and (B) the dorsal interiors of *Astraborthis*.

submedial lobes of diductor scars impressed on the floor of a strong pseudospondylium; mantle canal pattern saccate.

Dorsal interior with a simple plate-like cardinal process and short, blade-like outward-curving brachiophores embedded in a thick deposit of secondary shell; sockets oblique, notothyrial platform weak, fused with median ridge; adductor scars quadripartite with smaller posterior pair; mantle canal pattern probably digitate.

TYPE SPECIES. *Astraborthis uniplicata* sp. nov. from the Mytton Flags.

DISCUSSION. Although the new genus is obviously alimbellid in its general morphology, it differs from other members of the family in its ornament and certain aspects of its internal morphology. Externally it is immediately distinguishable from the smooth *Alimbella* and finely capillate *Medesia* in its coarse costellation and internally in the weak development of the notothyrial platform and the blade-like nature of the brachiophores. It further differs from *Alimbella* in its wide ventral adductor scar and from *Medesia* in the absence of branching and medial fusion of the proximal parts of the *vascula media*.

It may be of familial significance that dental plates have not yet been seen in adult pedicle valves of any of the three genera assigned to the Alimbellidae. It is, however, possible that short receding dental plates were developed during early growth stages but were later entirely buried in thick deposits of secondary shell secreted in the delthyrial cavity during formation of the pseudospondylium. Until young shells or their impressions have been examined it is safer to delay assessing the importance of this aspect of alimbellid morphology.

Astraborthis uniplicata gen. et sp. nov.

(Pl. II, figs. 5, 6, 9, II, 14; Text-fig. 6)

DIAGNOSIS. Subcircular, dorsibiconvex *Astraborthis* with the pedicle valve over four-fifths as long as wide and about one-third as deep as long; ventral sulcus rounded and about two-thirds as wide as the valve length, ornamented by angular costellae with a wavelength of about 1 mm, 10 mm anterior of the ventral umbo with 4 on the fold and up to 16 on the shell; pseudospondylium about one-third as long as the pedicle valve.

DESCRIPTION. Subcircular, strongly biconvex *Astraborthis* with the pedicle valve over four-fifths as long as wide and about one-third as deep as long; ventral sulcus flanked by evenly convex lateral slopes, rounded in profile, about two-thirds as wide as the length of the pedicle valve, projecting antero-dorsally to fit into rounded dorsal fold; brachial valve over one-third as deep as long, lateral slopes strongly and evenly convex; ventral interarea over one-quarter as long as the pedicle valve, dorsal interarea about one-eighth as long as the brachial valve, cardinal extremities obtusely rounded; radial ornamentation coarsely costellate with delayed costae originating at about 2 mm anterior of the umbo, with four occupying the crest of the fold, ribs sharply angular with a wavelength of about 1.0 mm at 10 mm anterior of ventral umbo.

Ventral interior with pseudospondylium elevated on a solid platform of secondary shell, about three-quarters as wide as long, lateral boundaries subparallel, anterior boundary rounded extending forward from the ventral umbo for one-third the length of the pedicle valve.

Dorsal interior with plate-like cardinal process obtusely triangular in lateral view, brachiophores short, curved, weakly divergent, adductor field strongly impressed divided by moderately strong median ridge and bounded posteriorly by weakly defined notothyrial platform.

TYPE MATERIAL.

		length	width (mm)
HOLOTYPE	Incomplete external and internal moulds of pedicle valve (BB 35324a, b)	10.5	12.5
PARATYPE	Incomplete external and internal moulds of brachial valve (BB 35325a, b)	—	—

HORIZON AND LOCALITY. Mytton Flags exposed in small pathside quarry in the north-trending valley, 160 yds north-east of the north-east corner of Snailbeach Reservoir (Grid Ref. SJ 378024).

DISCUSSION. Only the incomplete moulds of a brachial and a pedicle valve, possibly the disarticulated remains of one shell, have so far been recovered from the Mytton Flags but the generic and specific individuality of the specimens cannot be doubted. Further collecting is desirable not only to assess the variation that occurred within the species but also to determine whether dental plates were developed in young specimens and to resolve the complete ribbing pattern, which, judged on

the fragment of the dorsal exterior available at present, may have included about 16 costae, arising just anterior of the umbo.

Family **FINKELNBURGIIDAE** Schuchert & Cooper 1931

DIPARELASMA Ulrich & Cooper 1936

Diparelasma sp.

(Pl. II, figs. 3, 7, 8)

The internal and an incomplete external mould of two brachial valves, 2 and 3 mm long respectively, and an incomplete external mould of a pedicle valve, collected from the Mytton Flags are best assigned to the finkelnburgiid *Diparelasma*. The moulds of one brachial valve and the pedicle valve (BB 35335a, b) came from a small exposure, 20 yds west of a tunnel in the valley side north of the col separating Perkin's Beach and Mytton's Beach (Grid Ref. SJ 366002); those of the other brachial valve (BB 35336a, b) were obtained from outcrops near the top of the steep tributary to Crowsnest Dingle, 350 yds WNW of Blakemoorflat (Grid Ref. SJ 373008).

The moulds indicate that the shell was ventribiconvex and transversely subquadrate in outline with obtuse cardinal angles, had a sulcate brachial valve about 22% as deep as long and 64% as long as wide, and a pedicle valve about one-third as deep as long. Radial ornamentation was finely multicostellate with counts of 7 and 9 costellae per mm, 2 mm anterior of the umbones. The cardinalia consisted of blade-like brachiophores diverging from the anacline interarea with bases converging onto the floor of the valve on either side of a low median ridge to define a deep notothyrium containing a simple cardinal process. The fulcral plates were more strongly developed in the smaller valve as antero-lateral boundaries to the sockets. A pair of discrete adductor muscle scars extending anteriorly of the umbo for about half the length of the valve were impressed on either side of the median ridge.

Despite the lack of information about the ventral interior, the distinctive radial ornamentation and cardinalia leave little doubt that the moulds belong to *Diparelasma*. A number of species have been described from the Lower Ordovician, especially the Upper Canadian of N. America (Ulrich & Cooper 1938: 147-156); but the cardinal process and dorsal sulcus are more strongly developed in the Shropshire specimens and may eventually prove to be diagnostic of a new species.

Family **PLECTORTHIDAE** Schuchert & Le Vene 1929

Subfamily **PLECTORTHINAE** Schuchert & Le Vene 1929

PLECTORTHIS Hall & Clarke 1892

Plectorthis whitteryensis sp. nov.

(Pl. II, figs. 10, 13, 16, 17; Pl. 12, fig. 1)

DIAGNOSIS. Semi-elliptical, slightly ventribiconvex, rectimarginate *Plectorthis* with a pedicle valve 69% as long as wide and 22% as deep as long, ornamented by

up to 27 costellae numbering 2 per mm, 5 mm antero-medially of the umbo, and bearing hollow embayments along the crests; elongately oval ventral muscle scar extending forward for 28% of the length of the pedicle valve; cardinal process ridge-like, simple.

DESCRIPTION. Semi-elliptical, subequally biconvex *Plectorthis*, 3 pedicle valves averaging 69% as long as wide (range 64% to 73%) and 22% as deep as long (range 21% to 24%) tending to become flatter away from the greatest depth of the valve in the umbonal region, and an evenly convex brachial valve with a mean depth relative to length of 19% (range 16% to 22%) for 3 valves; anterior commissure rectimarginate, cardinal angles slightly obtuse; radial ornamentation evenly costellate with up to 27 flat-crested, parallel-sided costellae numbering 2 per mm, 5 mm antero-medially of the umbo and arising by dichotomy of primary costae within 0.5 mm of the umbo, costellae becoming hollow at intervals of about 0.5 mm, interspaces finely striate and imbricate; ventral interarea apsacline, delthyrium open, narrow, dorsal interarea shorter, anacline; notothyrium open.

Ventral interior with elongately oval muscle field averaging 74% (range 63% to 93%) as wide as long and 28% (no range) as long as the length of the valve for 3 pedicle valves, with well-developed submedial diductor lobes meeting antero-medially to enclose a lanceolate undifferentiated adductor scar; teeth small, supported by short subparallel to narrowly divergent dental plates extending anteriorly for an average of 9.5% the length of the valve for 2 valves.

Dorsal interior with a simple ridge-like cardinal process, brachiophores short, divergent, with bases slightly convergent to the floor of the valve and extending anteriorly for an average of 10% of the length for 3 valves; short fulcral plates defining small suboval sockets, median ridge absent, adductor scars only rarely impressed as a pair of widely spaced bilobed scars extending anteriorly for about two-fifths the length of the brachial valve; mantle canal systems unknown.

TYPE SPECIMENS.

		length	width (mm)
HOLOTYPE	External and internal moulds of pedicle valve (BB 35462a, b)	6.5	10.0
PARATYPES	External and internal moulds of brachial valve (BB 35463a, b)	5.0	—
	External and internal moulds of brachial valve (BB 35464a, b)	5.0	8.5
	External and internal moulds of pedicle valve (BB 37158a, b)	6.0	9.2

HORIZON AND LOCALITIES. Whittery Shales exposed in the lower part of the west bank of the River Camlad 60 yds north-east of Marrington Farm (Grid Ref. SO 272970).

DISCUSSION. Many Ordovician *Plectorthis* have been described, especially from North America (see Cooper 1956: 447-456), but the species collected from the Whittery Shales is unique in the combination of a number of distinctive features, in particular the semi-elliptical outline and the peripheral flattening of the pedicle

valve, the absence of a dorsal sulcus, the relative fineness of the costellate ornamentation, the variable development of a simple cardinal process and the occurrence of hollow embayments along the crests of the costae. Indeed, in respect of the last two features, the new species shows some affinity with *Desmorthis* Ulrich & Cooper 1936, and in view of the essential homogeneity of the American *Plectorthis* which suggests that they constitute a closely related species group, the Shropshire specimens may represent a stock with only remote ancestral links with their American contemporaries.

Plectorthis sp.

(Pl. II, figs. 12, 15)

A complete internal mould and a fragment of the external mould (BB 35466a, b) of an orthacean pedicle valve, collected from Aldress Shales exposed in a bank of Ox Wood Dingle at the south-west corner of Ox Wood, a few yards north of the Rorrington-Wotherton road (Grid Ref. SJ 290007), have been provisionally identified as *Plectorthis*. The valve, which was about 13 mm long and 14.5 mm wide, was subcircular in outline with obtusely rounded cardinal angles and just over one-sixth as deep as long becoming flatter antero-medially. The surface was ornamented by microscopic concentric lamellae and 24 ribs which must have arisen at or near the umbo except for a few secondary costellae in the lateral areas. The ribs were rounded with a wavelength of 0.6 mm, 10 mm anterior of the umbo, and were separated by interspaces about 0.5 mm wide. The interarea was short, curved, and aplanate, the delthyrium open, and the small teeth were supported by widely divergent dental plates extending anteriorly for less than one-sixth the length of the valve. No identifiable muscle scars were impressed on the floor of the valve.

In the absence of impressions of the brachial valve, no valid comparisons can be drawn with described *Plectorthis*. The pedicle valve, however, is immediately distinguishable from that of *P. whitteryensis* sp. nov. in its subcircular rather than semi-elliptical outline, its significantly fewer ribs which are, moreover, rounded not flattened, and its widely divergent dental plates.

DESMORTHIS Ulrich & Cooper 1936

Desmorthis ? sp. nov.

(Pl. 12, figs. 2-4, 8)

Incomplete external and internal moulds of a brachial valve (BB 35337a, b), from exposures in a runnel to the east of the footpath to Blakemoorflat at the head of Mytton's Beach (Grid Ref. SJ 373006), are the sole representatives in the Mytton Flags of a highly distinctive plectorthid genus. The valve which was 7 mm long, semi-oval in outline, rectimarginate and gently convex medially with flattened lateral slopes, was ornamented by strong, sharply rounded hollow costellae numbering 2 per mm, 5 mm antero-medially of the umbo, and a subdued concentric ornamentation of faint lamellae. The planar anacline interarea was about one-tenth as

long as the valve, the cardinal process a fine median ridge on a low notothyrial platform, separating two subtriangular diductor impressions. The short divergent brachiophores were pointed with low convergent bases bounding the notothyrial platform, while the narrow sockets were defined by well-developed fulcral plates. A linear median ridge extended anteriorly of the notothyrial platform for about two-fifths of the valve length, between suboval, poorly impressed adductor scars.

Two sets of external and internal moulds (BB 35338a, b ; BB 35339) from the Stapeley Volcanic Group collected from outcrops in an adit near Perkin's Beach, west of Shepherd's Rock, represent pedicle valves which appear to be conspecific with the brachial valve described above. The ornamentation, consisting of faint concentric lamellae and rather widely separated sharply rounded hollow costellae, is identical. Unfortunately little can be said about the internal morphology. In the larger specimen, which is 4 mm long, the ventral muscle field is not impressed and only the mould of a divergent dental plate, extending forward for about one-seventh the length of the mould, is seen.

The profiles of the valves, the development of hollow costellae and, with regard to the brachial valve from the Mytton Flags, the nature of the cardinalia are all indicative of the plectorthid affinities of the specimens. The simplicity of the cardinal process further suggests that the brachial valve, at least, is closer to *Desmorthis* than any other genus assigned to the family. However, the convergence of the brachiophores and the lamellose exterior hint that when the species is fully known it will prove to be generically distinct from other plectorthids.

GELIDORTHIS Havlíček

Gelidorthis cf. *partita* (Barrande)

(Pl. 12, figs. 5-7)

- 1879 *Orthis partita* Barrande : plate 63, fig. 11.
 1950 *Givaldiella partita* (Barrande, 1879) Havlíček : 124.
 1968 *Gelidorthis partita* (Barrande, 1879) Havlíček : 125.
 1971 *Gelidorthis partita* (Barrande, 1879) Havlíček : 42.

A small number of impunctate valves never more than 8 mm long, from the Rorrington Beds exposed in Spy Wood Brook 20 yds downstream from where it joins Deadman's Dingle (Grid Ref. SO 289958), most closely compare with *Gelidorthis partita* (Barrande) from the Lower and Middle Caradoc rocks of Czechoslovakia. The shells were subquadrate in outline with an evenly convex pedicle valve (BB 37159 ; BB 35418a, b) about three-quarters as long as wide and about one-eighth as deep as long, and a very gently convex brachial valve (BB 35419a, b) lacking a definite sulcus. The relatively coarse radial ornamentation consists of angular costellae numbering 3 per mm at 5 mm antero-medially of the ventral umbo. The ribbing is strongly impressed internally even in the ventral umbonal cavity which is defined by short, widely divergent dental plates extending forward for about one-tenth the length of the pedicle valve. As in the pedicle valve, the dorsal muscle field is also obscured by internal ribbing ; but the cardinalia are well developed and consist of a cardinal process incipiently differentiated into a myophore and shaft,

brachiophores supported by short convergent bases, and sockets defined by small fulcral plates.

These features are consistent with the variability described by Havlíček (1950 : 124 ; 1971 : 42) in young specimens of *G. partita*, although the brachial valve of the Shropshire *Gelidorthis* appears to be relatively flatter. However only two of these valves are known at present and until more material including adult specimens is available for the significance of this difference to be assessed, there is no justification in according them systematic recognition.

TAZZARINIA Havlíček 1971

Tazzarinia elongata sp. nov.

(Pl. 12, figs. 9-12, 15)

DIAGNOSIS. Elongately subquadrate, ventribiconvex *Tazzarinia* with a coarsely fascicostellate ornamentation and a dorsal sulcus dying out anteriorly ; bilobed ventral muscle scar extending forward for almost 30% the length of the pedicle valve ; pointed brachiophores supported by short bases.

DESCRIPTION. Subquadrate, ventribiconvex *Tazzarinia* with slightly obtuse cardinal angles ; pedicle valve almost as long as wide and one-quarter as deep as long, slightly carinate medially with evenly convex lateral slopes ; brachial valve about four-fifths as long as wide and one-sixth as deep as long, with a narrow median sulcus becoming indistinct beyond the 4 mm growth stage, lateral slopes evenly convex ; radial ornamentation strongly fascicostellate with narrowly rounded costellae numbering 5 per mm, 3.5 mm antero-medially of the dorsal umbo ; ventral interarea slightly curved apsacline, longer than the anacline dorsal interarea, notothyrium and delthyrium open but pedicle callist strongly developed within the latter.

Teeth supported by narrowly divergent dental plates extending forward for about one-sixth the length of the pedicle valve ; ventral muscle scar strongly bilobed with a median adductor track and flanking diductors impressed anteriorly for almost three-tenths the length of the valve.

Cardinal process massive with crenulated posterior face, notothyrial platform well developed passing anteriorly into median ridge and flanked by convergent bases of pointed brachiophores, sockets elongate with small fulcral plates ; suboval adductor scars impressed on either side of median ridge and extending anteriorly for over two-fifths the length of the brachial valve.

TYPE MATERIAL.

		length	width (mm)
HOLOTYPE	External and internal moulds of brachial valve (BB 35332a, b)	5.5	-
PARATYPE	External and internal moulds of pedicle valve (BB 35333a, b)	3.8	3.8

TYPE HORIZON AND LOCALITY. Meadowtown Beds exposed in a small excavation in the corner of a field alongside the cart-track from Meadowtown to Waitchley, 330 yds south of Waitchley (Grid Ref. SJ 311017).

DISCUSSION. Although the moulds of only one pedicle and one brachial valve of *Tazzarinia* have been recovered from the Meadowtown Beds, there is no doubt about their generic affiliations or their specific distinctiveness. The specimens compare in every important respect with the *Tazzarinia* described by Havlíček (1971 : 39) from the Lower Caradoc of Morocco except that bilobation of the cardinal process cannot be confirmed in the Shropshire dorsal mould. Yet the Shelve form is immediately distinguishable from both Moroccan species, *T. drotae* and *T. foraminosa*, especially in its coarsely fascicostellate ornamentation and its elongately subquadrate outline.

Subfamily **PLATYSTROPHIINAE** Schuchert & Le Vene 1929

PLATYSTROPHIA King 1850

Platystrophia caelata sp. nov.

(Pl. 12, figs. 13, 14, 16-19)

DIAGNOSIS. Subquadrate, dorsibiconvex *Platystrophia* with the pedicle valve 76% as long as wide and 32% as deep as long, with a flat-bottomed sulcus 54% as wide as the valve length, ornamented by 2 costae in the sulcus and 10 to 14 on the lateral slopes with lamellae extending along the crests of costae as short rounded canopies.

DESCRIPTION. Subquadrate, dorsibiconvex, uniplicate *Platystrophia* with subrectangular cardinal angles, the brachial valve just over two-fifths as deep as long, the pedicle valve on average 76% (range 70% to 79%) as long as wide and 32% (range 28% to 35%) as deep as long for 3 valves, with a flat-bottomed sulcus with a mean width of 54% (range 50% to 57%) relative to the length for 3 valves, and evenly convex lateral slopes; dorsal interarea short, anacline, ventral interarea curved, apsacline about one-fifth as long as pedicle valve; costae angular with a wavelength of just over 1 mm, 5 mm anterior of dorsal umbo, covered with densely distributed tubercles and numbering 2 in the ventral sulcus with 10 to 14 on the lateral slopes; lamellae strongly developed and, beyond 4 mm from umbones, extending along the crests of the costae as short, rounded canopies partially covering subtriangular concave pads of secondary shell.

Ventral interior with small pedicle callist, thick teeth supported by short, receding dental plates extending anteriorly for less than one-fifth the length of the pedicle valve, and subtriangular muscle field with wide adductor impressions occupying the floor of the valve, less than half as wide as long and extending anteriorly for just over two-fifths the length of the pedicle valve; mantle canal impressions obscure but ventral system possibly digitate with abbreviated *vascula media* occupying the

crests of the costae in the sulcus and gonocoels spreading antero-laterally along the crests of the lateral costae.

Dorsal interior with ridge-like cardinal process and wide notothyrium bounded by secondarily thickened short brachiophores extending anteriorly for about one-fifth the length of the brachial valve ; dorsal adductor impressions quadripartite, extending anteriorly for almost half the length of the brachial valve on either side of a low median ridge with the subtriangular anterior pair the larger.

TYPE MATERIAL.

		length	width (mm)
HOLOTYPE	External and internal moulds of brachial valve (BB 35493a, b)	9.5	—
PARATYPES	External and internal moulds of pedicle valve (BB 35494a, b)	9.0	11.7
	External and internal moulds of pedicle valve (BB 35495a, b)	10.5	15.0

HORIZON AND LOCALITIES. Whittery Shales : BB 35493 from Whittery Quarry at the south end of Whittery Wood, near Chirbury (Grid Ref. SO 275981) ; BB 35494, BB 35495 from exposures in the lower part of the west bank of the River Camlad, 60 yds north-east of Marrington Farm (Grid Ref. SO 272970).

DISCUSSION. The *Platystrophia* which occurs rarely in the Whittery Shales has a highly distinctive concentric ornamentation of differentially developed lamellae. Most *Platystrophia* are variably lamellose and some such as *P. chama* Eichwald (as figured by Alichova 1953 : 131) strikingly so, but in *P. caelata* sp. nov. more than 4 mm long strong lamellae occur at regular intervals of about 0.5 mm and their forward growth along the costae was accompanied by an equally regular sag of the mantle edge. The resultant pattern is a series of subcircular, narrow canopies, aligned along the crests of the costae, inclined at about 35° to the shell surface and overhanging the posterior parts of alternating, depressed, subtriangular areas of secondary shell. In the intercostate spaces, the lamellae lie flat on one another as a series of overlapping tongues directed anteriorly. This ornament is characteristic of all eight specimens of the genus collected from the Whittery Shales. It is unknown in any other described *Platystrophia*, and in recognition of its uniqueness a new species has been erected to include the Whittery shells.

In other features, the new species appears to be unexceptional, although this may be due to the meagreness of the sample. Judging from the clarity of gonadal impressions and muscle scars which are deeply inserted even on the notothyrial floor and about the cardinal process, specimens attaining a length of 10 mm were gerontic individuals so that at least the Whittery representatives of the species were small in size. All specimens showing the disposition of the costae on the fold and sulcus were biplicate. The interiors of both valves show less secondary thickening than is typical of later species of *Platystrophia*, but, even so, the brachiophore bases in the brachial valve are heavily encased in secondary shell as are the ventral umbonal chambers.

Platystrophia cf. *major* Williams 1955

(Pl. 13, figs. 1, 2, 4)

1955 *Platystrophia precedens* McEwan *major* Williams : 402.

The moulds of two immature valves of *Platystrophia* lacking the distinctive concentric ornamentation of *P. caelata* sp. nov. have also been found in the Shelve area. They are the moulds of a brachial valve nearly 5 mm long (BB 35586a, b) from Aldress Shales exposed in the bank of Ox Wood Dingle at the south-west corner of Ox Wood a few yards north of the Rorrington-Wotherton road (Grid Ref. SJ 290007), and a pedicle valve 5.5 mm long (BB 35587a, b) from the Spy Wood Grit exposed on top of the ridge 1440 yds NNE of the Rorrington bench mark 599 (Grid Ref. SJ 303018). Neither valve can be completely reconstructed from the indifferently preserved moulds but the brachial valve appears to have been about 80% as long as wide and 20% as deep as long with a well-defined rounded fold about 40% as wide as the valve. The radial ornamentation consists of 3 costae on the fold and 5 on each lateral slope with a wavelength of 0.7 mm, 5 mm antero-medially of the umbo. Only impressions of subparallel brachiophore bases and a blade-like cardinal process are preserved internally. The pedicle valve was similarly ornamented, although traces of fine concentric lamellae are also sporadically preserved, while internally the ventral muscle scar extended well beyond the slightly divergent dental plates for 36% of the valve length.

These few statistics and especially the presence of 3 costae on the fold and 2 in the sulcus suggest that both valves may be provisionally assigned to *P. major* Williams (in Whittington & Williams 1955 : 402) first described from the Derfel Limestone of N. Wales. The species is morphologically like the American species *P. precedens* McEwan but is now also known from the Upper Llandeilo (MacGregor 1961 : 184). New evidence on intraspecific variability in the arrangement of costae suggests that the species is more likely to be related to the *Platystrophia dentata* (Pander) group from the Baltic (Williams 1963 : 371).

MCEWANELLA Foerste 1920*Mcewanella* sp.

(Pl. 13, figs. 3, 5)

An incomplete pedicle valve (BB 35416) and a deformed internal ventral mould (BB 35417) from the Whittery Shales exposed in the stream at the north end of Spring Coppice 865 yds south-east of Hockleton Bridge (Grid Ref. SO 279997) are the only specimens of *Mcewanella* so far recovered in the Shelve area.

Growth lines on the valve which was about half as deep as long, and shallowly sulcate antero-medially, indicate that the outline changed from semi-circular to subquadrate during growth, because the immature valve was widest along the mucronate hinge-line whereas fully developed valves were about as wide as long with the maximum width well anterior of the hinge line with its orthogonal cardinal angles. The external surface was ornamented by branching costellae numbering

3 per mm, 5 mm antero-medially of the umbo and further corrugated by up to 7 radiating rounded costae with a wavelength of about 3 mm, 10 mm antero-medially of the umbo.

The ventral mould is distorted umbonally but there is evidence of an apsacline interarea and massive trigonal teeth supported by strong, narrowly divergent dental plates. The ventral muscle scar was elongately oval with a broad median adductor track reaching to the anterior margin.

The specimens are closely related to the Upper Llandeilo *M. berwynensis* (MacGregor 1961: 183). However, the Welsh *Mcewanella* bears a ventral fold, and 9 superimposed costae, and until the variability of these features can be ascertained in the Shropshire form it seems safer to withhold specific identification.

SALACORTHIS gen. nov.

NAME. An orthacean with an external ornament like a sieve (Gk. *σάλαξ*).

DIAGNOSIS. Subquadrate, biconvex, uniplicate shells with a strong dorsal median fold emerging from a neanic sulcus and a complementary ventral sulcus; radial ornamentation coarsely costate to costellate with two or three thick rounded costae on the fold and up to three equally wide costae on each lateral slope, costellae arising sporadically in later growth stages either by division of costae or as intercalations in the interspaces; external shell surface also ornamented by densely distributed, deep exopuncta arranged quincuncially; ventral interarea curved, apsacline with open triangular delthyrium, dorsal interarea shorter, slightly curved anacline, notothyrium open; shell impunctate.

Ventral interior with strong teeth supported by short but well-defined dental plates extended on the valve floor as raised ridges laterally bounding an elongately oval undifferentiated muscle field; ventral mantle canal system unknown.

Dorsal interior with a wide notothyrial platform bearing a median ridge-like cardinal process, brachiophores rod-like, divergent, continuous laterally with strong concave fulcral plates defining oblique, hemiconical sockets; brachiophore bases large, convergent onto notothyrial platform and median ridge; dorsal adductor scars divided by median ridge into a pair of triangular undifferentiated impressions with the apices directed posteriorly and deeply inserted beneath the anterior borders of the brachiophore bases; dorsal mantle canal system unknown.

TYPE SPECIES. *Salacorthis costellata* sp. nov. from the Spy Wood Grit.

DISCUSSION. The new genus, with the exception of a poorly preserved exfoliated pedicle valve revealing the impunctate nature of the shell, is represented solely by a few moulds from the Spy Wood Grit. Yet its affinities are not in doubt because it combines the typical cardinalia of the Plectorthidae with the coarsely costate ornamentation and strongly uniplicate anterior margin of the Platystrophinae. Indeed with regard to its radial ornamentation it anticipates the relationship between *Platystrophia* and *Mcewanella* (Schuchert & Cooper 1932: 69). The former is costate and the latter is believed, at least in respect of the American species, to have been

derived from *Platystrophia* by the superimposition of a multicostellate ornament. The beginnings of a similar development can be seen in one external mould of *Salacorthis* (Pl. 13, fig. 12) but it was not necessarily typical of the species because no costellae were developed in a larger pedicle valve and even in the figured specimen costellae did not appear until the valve was about 7 mm long. The new genus therefore differs from both *Platystrophia* and *Mcewanella* in being sporadically costellate.

The principal difference, however, and one which immediately distinguishes *Salacorthis* from the other two members of the Platystrophiinae, lies in the conspicuously exopunctate appearance of the shell surface. The exopuncta were deep coarse pits penetrating the external shell vertically for depths of about 0.1 mm and arranged in a closely crowded quincuncial pattern. They are quite different in morphology and origin from the obliquely disposed apertures which constitute the 'hollow ribs' so typical of the plectorthids (Williams in Williams *et al.* 1965 : H70), and are all the more unexpected because the external surface of *Platystrophia* is noteworthy among orthaceans for being distinctively pustulose.

Internal characters that indicate the platystrophiinid affinities of *Salacorthis* include the simple cardinal process and the suboval ventral field which, although undifferentiated in known specimens of the new genus, probably consisted of a broad adductor scar flanked by elongate bases for the diductors and adjustors, as in *Platystrophia*. The brachiophores and their supporting bases are also comparable, although the degree to which the posterior parts of the dorsal adductor impressions are inserted behind the brachiophore bases of *Salacorthis* is unmatched in *Platystrophia* and *Mcewanella*. But such internal differences as exist are minor and do not affect the conclusion that *Salacorthis* arose out of the earlier established *Platystrophia*.

***Salacorthis costellata* gen. et sp. nov.**

(Pl. 13, figs. 6-13 ; Text-fig. 7)

DIAGNOSIS. Dorsibiconvex, subquadrate *Salacorthis* with a brachial valve about three-quarters as long as wide and 37% as deep as long ; dorsal fold almost half as wide as valve length, bearing 2 or 3 costae with a wavelength of 1.5 mm, 5 mm antero-medially of the umbo, with 2 or 3 on the flanks, all becoming costellate in late growth stages ; ventral muscle scar suboval extending forward for nearly one-third the length of the pedicle valve ; dorsal median septum short.

DESCRIPTION. Dorsibiconvex, subquadrate *Salacorthis* with cardinal angles becoming obtuse in adult growth stages, pedicle valve about one-quarter as deep as long, brachial valve three-quarters as long as wide with a mean depth relative to length of 37% for 3 brachial valves ; dorsal fold 49% as wide as the length of 3 brachial valves bearing 2 or 3 strong costae with a wavelength of about 1.5 mm, 5 mm antero-medially of the dorsal umbo, with 2 or 3 additional costae on each of the lateral slopes, all costae may split into costellae in late growth stages ; exopuncta coarse with counts of 3 per 0.5 mm, 5 mm anterior of the umbo.

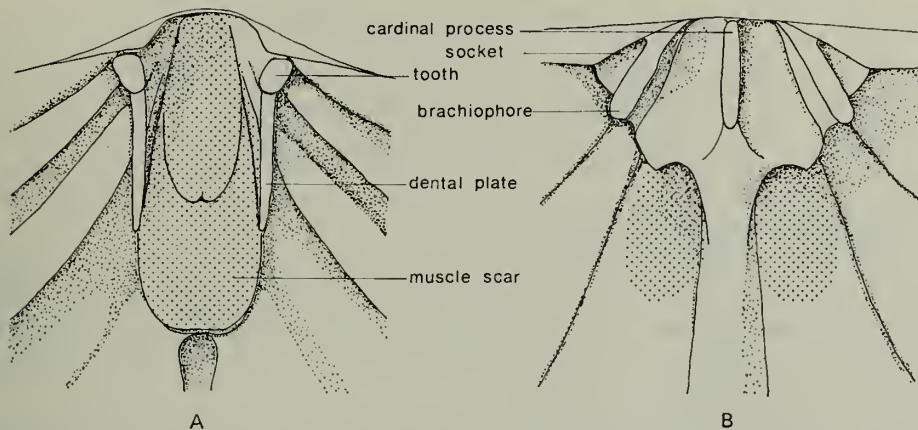


FIG. 7. Diagrammatic views of (A) the ventral and (B) the dorsal interiors of *Salacorthis*.

Ventral interior with subparallel dental plates extending forward for one-seventh the pedicle valve length, suboval ventral muscle scar undifferentiated, extending anteriorly for nearly one-third the length of the pedicle valve.

Dorsal interior with brachiophore bases extending forward for over one-quarter the length of the brachial valve ; median septum supporting the cardinalia short, extending anteriorly for two-fifths the length of the brachial valve.

TYPE MATERIAL.

		length	width (mm)
HOLOTYPE	External and internal moulds of brachial valve (BB 37153a, b)	3.7	5.0
PARATYPES	Internal mould of pedicle valve (BB 37154)	11.0	12.0
	Incomplete external mould of brachial valve (BB 37155)	—	—
	Incomplete external mould of brachial valve (BB 37156)	—	—
	Incomplete external mould of brachial valve (BB 37157)	4.5	—

HORIZON AND LOCALITIES. Spy Wood Grit : BB 37153, 37154 from exposures on top of ridge 1440 yds NNE of Rorrington bench mark 599 (Grid Ref. SJ 303018) ; BB 37155, 37157 from outcrops 1100 yds NNE of Rorrington (Grid Ref. SJ 303015) ; BB 37156 from outcrops in the north bank of Spy Wood Brook 170 yds north-east of Spy Wood Cottage (Grid Ref. SO 282958).

DISCUSSION. No other species congeneric with *Salacorthis costellata* has yet been so described although in view of the strongly developed platystrophiid characters of the Spy Wood form and the microscopic nature of its chief differentiating feature, some stocks, currently recorded as *Platystrophia* or *Mcewanella*, may ultimately prove to belong to the genus.

Family **SKENIDIIDAE** Kozłowski 1929
 Genus **SKENIDIOIDES** Schuchert & Cooper 1931
Skenidioides cf. *costatus* Cooper
 (Pl. 13, figs. 14-16 ; Pl. 14, figs. 1-3)

1956 *Skenidioides costatus* Cooper : 493.

1963 *Skenidioides* cf. *costatus* Cooper ; Williams : 375.

DIAGNOSIS. Subpyramidal, ventribiconvex *Skenidioides* with a carinate pedicle valve 54% as long as wide and 55% as deep as long, ornamented by up to 8 costae on each of the lateral slopes and a thick median costa giving rise to a pair of lateral costellae 1.5 mm anterior of the umbo.

DESCRIPTION. Semi-oval, sulcate *Skenidioides* with a subpyramidal, carinate pedicle valve with a mean length relative to width of 54% (range 50% to 59%) for 4 valves and a mean depth relative to length of 55% (range 53% to 58%) for 3 valves ; brachial valve very gently convex with a sharp median sulcus ; radial ornamentation costate with up to 8 rounded costae occupying each lateral slope but with ventral carina defined by thick rounded costa, about 0.5 mm in wavelength 2 mm anterior of ventral umbo, giving rise to a pair of lateral costellae about 1.5 mm anterior of ventral umbo.

Ventral interior with free spondylium about one-fifth as deep as the length of the valve.

Dorsal interior with thin and plate-like cardinal process continuous with high median septum, brachiophore bases converging onto dorsal septum at an average of 33% the length of 2 brachial valves ; dorsal adductor field as a pair of subtriangular impressions divided by median septum and extending anteriorly for nearly three-fifths the length of the brachial valve.

FIGURED MATERIAL.

	length	width (mm)
Internal mould of brachial valve (BB 35409)	2.3	4.4
Incomplete internal mould of pedicle valve (BB 35410)	2.5	4.4
Internal mould of pedicle valve (BB 35411)	1.2	2.7
Internal mould of pedicle valve (BB 35412)	0.8	1.5
Incomplete external mould of pedicle valve (BB 35413)	1.5	—

HORIZONS AND LOCALITIES. Spy Wood Grit : BB 35411 to 35413 from exposures in north bank of Spy Wood Brook, 170 yds north-east of Spy Wood Cottage (Grid Ref. SO 282958). Whittery Shales : BB 35409 from exposures in the lower part of the west bank of the River Camlad, 60 yds north-east of Marrington Farm (Grid Ref. SO 272970) ; BB 35410 from exposures in the stream at the north end of Spring Coppice, 865 yds south-east of Hickleton Bridge (Grid Ref. SO 279997).

DISCUSSION. Moulds of *Skenidioides* occur only rarely in both the Spy Wood Grit and Whittery Shales but are clearly related to the species found in the Gelli-grin

Calcareous Ashes which has been compared with *S. costatus* Cooper from the Porterfield of North America (Williams 1963 : 375). In internal proportions and the shape of the shell the likeness is certainly close and, although the Shelve pedicle valve tended to be relatively wider and deeper than the average Bala one, the differences are not important. Indeed the only indication of a difference which may eventually prove to be important is in the lack of development of a costellate ornamentation on the Shelve *Skenidioides*. The sample is indistinguishable from *S. costatus* in the number and wavelength of costae, but only the ventral median costa of the Shelve specimens gave rise to costellae, whereas external branches arose freely from the lateral costae of the Bala stock. This difference is not entirely related to the overall greater size attained by the Bala shells. Within the size range of the Shelve specimens, which are between 0.8 and 2.0 mm long, costellae branched from one or more lateral costae in 7 out of 12 pedicle valves from the Gelli-grin Group. It is therefore possible that the Shelve *Skenidioides* were characterized by a simplicity of ribbing that persisted throughout growth, but larger collections will have to be obtained to determine whether taxonomic recognition of the difference is worth while.

PROTOSKENIDIOIDES gen. nov.

NAME. One of the first skenidiids.

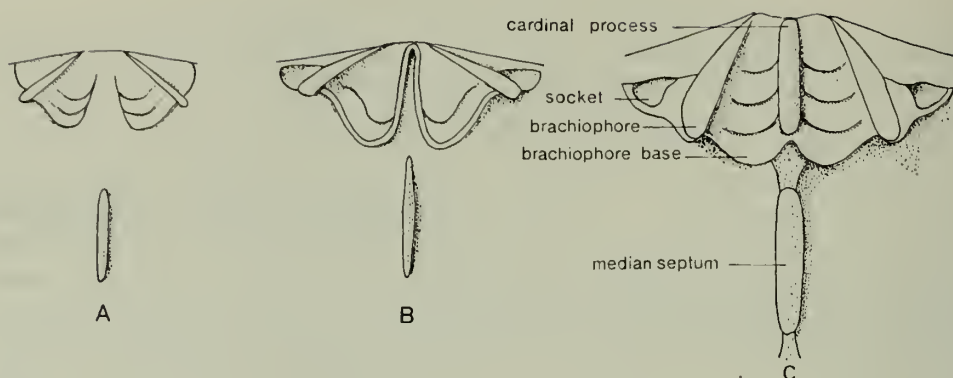
DIAGNOSIS. Transversely semi-oval, plano-convex shells with a high carinate pedicle valve and sharply sulcate brachial valve; radial ornamentation costate with a wide ventral median costa forming the carina of the pedicle valve and corresponding to the dorsal sulcus; ventral interarea long, planar, apsacline with an open delthyrium, dorsal interarea shorter, planar, anacline; shell probably impunctate.

Ventral interior with pointed teeth and shallow spondylium apparently free of the valve floor; muscle and mantle canal impressions unknown.

Dorsal interior with divergent brachiophores supported by flat-lying brachiophore bases, discrete and transversely lobate in young shells but extending anteriorly as elevated plates in adult shells and converging medially to form a ridge-like cardinal process which is joined by a low swelling on the valve floor with a high long median septum; sockets narrow oblique, defined by concave elevated fulcral plates in adult shells only; adductor muscle field divided by median septum into two elongated oval impressions bounded laterally by raised curved ridges; dorsal mantle canal system unknown.

TYPE SPECIES. *Protoskenidioides revelata* sp. nov. from the Mytton Flags.

DISCUSSION. The skenidiid found in the Mytton Flags is represented exclusively by fragile moulds of what must have been thin-shelled valves, but although the smallest impression of the brachial valve recovered is about 4 times as long as that of the protegulum, the size range (0.8 mm to 2.0 mm in valve length) is sufficiently great to reveal some hitherto unsuspected aspects of the origin and development of the skenidiid cardinalia.



	A	B	C
length (mm)			
0-0.9	5	1	
1.0-1.4		2	
1.5-2.0		1	4

FIG. 8. Diagrammatic views of the dorsal interiors of *Protoskenidioides* showing three stages (A, B, C) in the development of the cardinalia during ontogeny; with a correlation table below indicating the relationship between the length of the brachial valve and the illustrated growth stages of the cardinalia.

The smallest moulds show that when brachial valves were less than 1 mm long the brachiophores were well developed and widely divergent (Text-fig. 8). Posterolaterally they were flanked by simple slot-like sockets indented on the valve floor. Antero-medially they were continuous with a pair of transversely oval areas defined by slightly elevated anterior boundaries that converged towards the notothyrial apex of the valve. It is assumed that these wide, discrete areas represented the seats for the attachment of the dorsal ends of the diductor muscles rather than supports for the brachiophores although it is convenient to refer to them as brachio-phore bases. At this growth stage there was no notothyrial platform and the valve interior was dominated by the median elevation representing the external sulcus bearing a small, thin, median septum.

With further growth the antero-lateral parts of the sockets were raised above the valve floor by the development of concave fulcral plates and the brachio-phore bases were extended anteriorly as a pair of lobate platforms which were also free of the valve floor. The bases also encroached onto the median elevation which bore a small ridge in some valves, finally to converge and form a simple cardinal process clearly made up of the adjacent borders of the brachio-phore bases and contained within a low, anteriorly bilobed septalium. Concomitantly the median septum

extended anteriorly and also posteriorly almost to unite with the cardinal process from which it was separated by a low saddle representing a remnant of the median elevation.

These modifications leading to the definition of the septalium are unknown in younger skenidiids and serve to distinguish *Protoskenidioides* from other members of the family. In *S. cf. costatus* Cooper from the Gelli-grin Group, for example, impressions of the smallest brachial valves known, which are just over 1 mm long, show that the septalium was not bilobed but evenly convex anteriorly as in adult valves, and that it contained a high cardinal process not yet differentiated into a myophore and shaft but which was continuous with the median septum and bore no sign of having been built up from the median edges of the brachiophore bases.

The likelihood that *Protoskenidioides* gave rise to *Skenidioides* by an accelerated development of a well-defined septalium is strengthened by the close comparison between the two genera in other characteristics such as the distinctive shape and ornamentation. Even the inference that the spondylium in the pedicle valve of *Protoskenidioides* is free does not militate against the relationship because a septal support to the spondylium of *Skenidioides* cannot always be identified without recourse to apical sections of the shell. Such a line of descent is also still consistent with the suggestion (Kozłowski 1929 : 129) that the skenidiids were derived from the finkelnburgiids : indeed the attitude of the slightly inclined, convergent brachiophore bases of *Protoskenidioides* is more reminiscent of *Finkelnburgia* than the later skenidiids.

***Protoskenidioides revelata* gen. et sp. nov.**

(Pl. 14, figs. 4-13 ; Text-fig. 8)

DIAGNOSIS. Subpyramidal, mucronate *Protoskenidioides* with a planar brachial valve 47% as long as wide, lateral slopes ornamented by up to 18 costae with a broad ventral median costa corresponding to a dorsal sulcus 0.4 mm wide, 1.5 mm antero-medially of the umbo.

DESCRIPTION. Transversely semi-oval, mucronate *Protoskenidioides* with a subpyramidal pedicle valve and a planar brachial valve averaging 47% (range 45% to 48%) as long as wide for 4 valves with a well-defined rounded median sulcus consistently 0.4 mm wide, 1.5 mm antero-medially of the umbo of 4 valves ; radial ornamentation on lateral slopes consisting of up to 18 costae increasing in number during growth by implantation with the right lateral consistently 0.2 mm wide in 4 valves, and the ventral median costa complementary to the dorsal sulcus about 0.6 mm wide in adult shells.

Ventral interior with shallow spondylium, broadly convex anteriorly.

In adult brachial valves the septalium, about half as long as wide, extended anteriorly for an average of 23% (range 21% to 26%) the length of 5 valves but it was not continuous with a long median septum which may have reached the anterior

margin, adductor muscle field extending anterior of dorsal umbo for almost three-quarters the length of the valve.

TYPE MATERIAL.

		length	width (mm)
HOLOTYPE	Internal mould of brachial valve (BB 35387)	1·7	3·0
PARATYPES	External and internal moulds of brachial valve (BB 35388a, b)	1·3	2·6
	Incomplete internal mould of pedicle valve (BB 35389)	—	—
	Incomplete internal mould of brachial valve (BB 35390)	1·2	—
	Incomplete external mould of brachial valve (BB 35391)	—	—
	Incomplete internal mould of brachial valve (BB 35392)	0·8	—
	Incomplete internal mould of brachial valve (BB 35393)	1·1	—
	External and internal moulds of brachial valve (BB 35394a, b)	1·6	—
	External and internal moulds of pedicle valve (BB 35395a, b)	1·1	2·0
	Internal mould of brachial valve (BB 35396)	1·9	—
	External and internal moulds of brachial valve (BB 35397a, b)	1·6	—
	External and internal moulds of brachial valve (BB 35398a, b)	1·5	—
	External and internal moulds of brachial valve (BB 35399a, b)	1·7	—
	External and internal moulds of brachial valve (BB 35400a, b)	2·0	—
	External and internal moulds of brachial valve (BB 35401a, b)	0·9	1·7

HORIZON AND LOCALITIES. Mytton Flags : BB 35387 to 35393, BB 35398, 35399 from a trench excavated in Shelve Church Beds (Grid Ref. SO 335990) ; BB 35394 to 35397 from exposures of Shelve Church Beds along a cart-track near Wood House, Gravels (Grid Ref. SJ 338003) ; BB 35400, 35401 from Shelve Church Beds exposed along a cart-track 50 yds north-west of Wood House, near Gravels (Grid Ref. SJ 337002).

DISCUSSION. The moulds of the new species that have been collected are so closely crowded and so commonly collapsed that only a few statistical data were obtainable to indicate the variability of the new species. These are included in the description given above.

Superfamily ENTELETACEA Waagen 1884

Family SCHIZOPHORIIDAE Schuchert & Le Vene 1929

Subfamily DRABOVIINAE Havlíček 1950

DRABOVIA Havlíček 1950*Drabovia* cf. *fascicostata* Havlíček

(Pl. 14, figs. 14-16, 18, 19)

1950 *Drabovia fascicostata* Havlíček : 15.1950 *Drabovia fascicostatata* Havlíček : 47.1950 *Drabovia fascicostata* Havlíček : 47.

DIAGNOSIS. Ventribiconvex *Drabovia* ornamented by fascicostellae with about 5 ribs per mm, 5 mm antero-medially of dorsal umbo.

DESCRIPTION. Semi-elliptical, ventribiconvex, sulcate *Drabovia*, with orthogonal cardinal angles of young shells becoming obtuse in mature growth stages so that the hinge line is less than the maximum width of the shell; carinate pedicle valve 33% as deep as long, brachial valve 73% as long as wide and 15% as deep as long (the mean for 4 valves) with an evenly concave sulcus and evenly convex sides; ventral interarea relatively short, curved apsacline, dorsal interarea very short anacline, delthyrium and notothyrium open; radial ornamentation fascicostellate, divided into sectors by capillae, with counts of 6 and 5 ribs per mm occurring 5 mm antero-medially of the umbones of 1 and 4 brachial valves respectively, costellae branching internally in valves up to 5 mm long with 1ā, 2ā, 3ā and 4ā occurring early but with 3a°)3ā1ā, 3a°)3ċ and 4a°)4b present (costellae insertion code of Bancroft, 1945).

Cardinal process with a very small bulbous myophore and relatively long linear shaft, becoming thicker in mature valves, continuous with median ridge-like posterior part of sulcus; brachiophores short, acutely divergent, bases 17% as long as the brachial valve, parallel or convergent with the median ridge, sockets rarely defined by fulcral plates; muscle scar unknown.

Teeth small supported by slightly divergent dental plates extending forward for 16% the length of the pedicle valve; ventral muscle field subcordate with broad adductor scar bounded laterally by lobate diductor scars impressed anteriorly for about one-quarter the pedicle valve length.

FIGURED MATERIAL.

	length	width (mm)
External and internal moulds of brachial valve (BB 35316a, b)	4.0	4.8
External and internal moulds of brachial valve (BB 35317a, b)	4.5	9.4
External and internal moulds of pedicle valve (BB 35318a, b)	4.5	5.2
External and internal moulds of pedicle valve (BB 35319a, b)	5.5	7.5

HORIZON AND LOCALITY. Spy Wood Grit exposed 1100 yds NNE of Rorrington (Grid Ref. SJ 303015).

DISCUSSION. The first *Drabovia* recorded in the British Isles is represented by a small number of moulds (Tables 51-54) which compare closely with *D. fascicostata* Havlíček (1950: 47) from the Caradocian Letná Beds of Czechoslovakia. The ribbing of the Shropshire specimens may prove to be finer and the pedicle valve more convex but, provisionally at least, these differences are less important than the many points of resemblance.

TABLE 51

Statistics of length (l) and maximum width (w) of 17 brachial valves of *Drabovia* cf. *fascicostata* Havlíček

l mm (var l)	2.71 (1.192)
w mm (var w)	3.71 (1.361)
r	0.956
a (var a)	1.1068 (0.00647)

TABLE 52

Statistics of length (l) and maximum depth (th) of 7 pedicle valves of *Drabovia* cf. *fascicostata* Havlíček

l mm (var l)	3.21 (1.231)
th mm (var th)	1.06 (0.069)
r	0.988
a (var a)	0.2375 (0.00028)

TABLE 53

Statistics of length (l) of 8 pedicle valves and the length of dental plates (dl) of *Drabovia* cf. *fascicostata* Havlíček

l mm (var l)	3.47 (0.931)
dl mm (var dl)	0.57 (0.043)
r	0.837
a (var a)	0.2161 (0.00233)

TABLE 54

Statistics of length (l) and the length of brachiophore bases (lc) in 8 brachial valves of *Drabovia* cf. *fascicostata* Havlíček.

l mm (var l)	3.52 (0.831)
lc mm (var lc)	0.59 (0.015)
r	0.820
a (var a)	0.1367 (0.00102)

NOCTURNIELLA Havlíček 1950

Nocturniella sp.

(Pl. 14, figs. 17, 20)

The internal mould (BB 35341) of a brachial valve, about 4 mm long and 4.5 mm wide, is the only draboviinid so far recovered from the Mytton Flags -70 yds north

of the entrance to Yewtree Level, The Hollies, Snailbeach (Grid Ref. SJ 380018). The valve was subcircular in outline and about one-sixth as deep as long with evenly convex lateral areas and a strong median sulcus, represented by a broad median ridge on the valve interior, becoming fainter anteriorly. Internal impressions of ribbing indicate that the valve tended to be multicostellate with 5 costellae per mm at the antero-medial margin. The short planar interarea is anacline, divided medially by a notothyrium with a low platform bearing a linear cardinal process, and bounded by short pointed brachiophores with subparallel bases extending forward for one-eighth the length of the valve and sockets defined by fulcral plates. The adductor muscle scar impressions are faint and incomplete.

In the absence of impressions of the pedicle valve, identification of the specimen is not a certainty. However, the presence of a sulcus and the subparallel attitude of the brachiophore bases favour its assignment to *Nocturniella*. Yet it is quite distinct from the only described species of that genus, *N. nocturna* Barrande from the Arenig Komarov Beds of Czechoslovakia (Havlíček 1950 : 125), especially in the plate-like aspect of its cardinal process and the anterior suppression of the sulcus.

Family DALMANELLIDAE Schuchert 1913

DALMANELLA Hall & Clarke 1892

Dalmanella parva Williams emended

(Pl. 15, figs. 1-4, 7)

1949 *Dalmanella parva* Williams : 169.

DIAGNOSIS. Small, ventribiconvex *Dalmanella* with a brachial valve 77% as long as wide, and with fine costellae, rarely branching externally, numbering about 6 per mm at the 2 mm growth stage ; dental plates 23% as long as the pedicle valve and 130% as divergent as long ; subparallel brachiophore bases 22% as long as the brachial valve and separated from each other by 97% of their length.

DESCRIPTION. Small, ventribiconvex *Dalmanella* with obtuse cardinal angles ; pedicle valve 32% as deep as long with a carinate rounded median zone and evenly sloping lateral areas ; brachial valve 77% as long as wide and about one-fifth as deep as long with a shallow median sulcus almost three-quarters as wide as valve length flanked by evenly convex lateral areas ; ventral interarea slightly curved apsacline longer than anacline dorsal interarea, delthyrium and notothyrium open, pedicle callist usually conspicuous ; radial ornamentation costellate commonly 6 per mm, 2 mm antero-medially of the dorsal umbo ; branching simple, rarely developing secondaries especially externally (only 3 external costellae observed in sectors III and IV of 24 well-preserved exteriors).

Teeth small, supported by dental plates extending anteriorly for 23% the length of the pedicle valve and diverging for 130% their length ; ventral muscle field bilobed with diductor scars extending anteriorly for 35% the length of the pedicle valve but not surrounding the median adductor field ; *vascula media* slightly divergent, remaining mantle canal system obscure.

Cardinal process consisting of linear shaft and small rounded myophore ; brachio-phores short divergent, with subparallel bases flanking well-developed notothyrial platform extending anteriorly for 22% of the length of the brachial valve and separated from each other by 97% of their length ; adductor scars poorly differentiated, suboval, situated on either side of low median ridge and extending anteriorly for 59% of the length of the brachial valve.

FIGURED MATERIAL.

	length	width (mm)
Internal mould of brachial valve (BB 35434)	4·0	—
Internal mould of pedicle valve (BB 35435)	3·5	—
Internal mould of brachial valve (BB 35436)	3·0	—
External mould of brachial valve (BB 35437)	4·0	—

HORIZON AND LOCALITY. Lower Llandeilo yellow-weathering calcareous sandstones exposed in quarry 300 yds west of Ysgubor-wen Farm, Llandeilo (Grid Ref. SN 644224).

Dalmanella salopiensis sp. nov.

(Pl. 15, figs. 5, 6, 8-12)

DIAGNOSIS. Small, ventribiconvex *Dalmanella* with a brachial valve 77% as long as wide and 15% as deep as long and fine costellae, rarely branching externally, commonly numbering 6 per mm at the 2 mm growth stage ; dental plates 21% as long as the pedicle valve and 159% as divergent as long ; ventral muscle scar extending anteriorly for 35% of the length of the pedicle valve ; subparallel brachio-phore bases 22% as long as the brachial valve and separated from each other by 86% of their length.

DESCRIPTION. Small, subquadrate, ventribiconvex *Dalmanella* with obtuse cardinal angles ; pedicle valve 38% as deep as long with rounded carina medially and evenly sloping lateral areas, brachial valve 77% as long as wide and 15% as deep as long with shallow median sulcus about four-fifths as wide as valve length flanked by evenly convex lateral areas ; ventral interarea slightly curved apsacline, longer than anacline dorsal interarea, delthyrium and notothyrium open ; radial ornamentation of costellae commonly 6 per mm 2 mm antero-medially of the dorsal umbo ; branching simple, rarely developing externally with only 4 external ribs observed in 32 mature brachial valves.

Teeth supported by dental plates extending anteriorly for 21% the length of the pedicle valve and extending laterally to 159% of their length ; ventral muscle scar bilobed extending anteriorly for 35% of the length of the pedicle valve ; mantle canal system unknown.

Cardinal process consisting of linear shaft and compact myophore on a well-developed notothyrial platform ; brachio-phores short, divergent with subparallel bases extending anteriorly for 22% of the length of the brachial valve and separated

from each other by 86% of their length ; adductor scars suboval, faintly impressed on either side of low median ridge and extending anteriorly for 59% of the length of the brachial valve.

TYPE MATERIAL.

		length	width (mm)
HOLOTYPE	External and internal moulds of brachial valve (BB 35446a, b)	3.0	3.8
PARATYPES	External and internal moulds of pedicle valve (BB 35447a, b)	3.2	3.7
	External and internal moulds of brachial valve (BB 35448a, b)	1.6	2.4
	External and internal moulds of brachial valve (BB 35449a, b)	1.7	2.5
	External and internal moulds of brachial valve (BB 35450a, b)	2.5	3.2

TYPE HORIZON AND LOCALITIES. Meadowtown Beds : BB 35446 from loose flags by the side of Minicop Farm (Grid Ref. SJ 314018) ; BB 35450 from flags in Quinton's Quarry in the field 200 yds north-east of the chapel at Meadowtown (Grid Ref. SJ 312013) ; BB 35448-9 from tuffaceous flags 100 yds south-east of Minicop Farm (Grid Ref. SJ 315018) ; BB 35447 from shales along Meadowtown-Rorrington road 220 yds from Meadowtown Chapel (Grid Ref. SJ 309012).

Dalmanella salopiensis gregaria sp. et subsp. nov.

(Pl. 15, figs. 13-16, 20)

DIAGNOSIS. Like *Dalmanella salopiensis* but with a brachial valve 74% as long as wide and 16% as deep as long ; dental plates 19% as long as the pedicle valve and 184% in lateral extent as long ; ventral muscle scar 36% as long as the pedicle valve ; subparallel brachiophore bases 23% as long as the brachial valve and separated from each other by 91% of their length.

TYPE MATERIAL.

		length	width (mm)
HOLOTYPE	External and internal moulds of brachial valve (BB 35443a, b)	2.5	3.5
PARATYPES	External and internal moulds of pedicle valve (BB 35444a, b)	2.4	2.8
	External and internal moulds of brachial valve (BB 35445a, b)	-	2.8
	Internal and external moulds of pedicle valve (BB 35407a, b)	3.8	5.0

TYPE HORIZON AND LOCALITY. Spy Wood Grit exposed in north bank of Spy Wood Brook, 170 yds north-east of Spy Wood Cottage (Grid Ref. SO 282958).

Dalmanella salopiensis transversa sp. et subsp. nov.

(Pl. 15, figs. 17-19, 21-24; Pl. 16, fig. 1)

DIAGNOSIS. Like *Dalmanella salopiensis* but with a brachial valve 73% as long as wide and about one-tenth as deep as long; dental plates 20% as long as the pedicle valve and 192% in lateral extent as long; subparallel brachiophore bases 22% as long as the brachial valve.

TYPE MATERIAL.

		length	width (mm)
HOLOTYPE	External and internal moulds of brachial valve (BB 35438a, b)	3.4	4.2
PARATYPES	External and internal moulds of pedicle valve (BB 35439a, b)	3.5	-
	External and internal moulds of brachial valve (BB 35440a, b)	2.5	3.5
	External and internal moulds of pedicle valve (BB 35441a, b)	2.5	3.0
	External and internal moulds of pedicle valve (BB 35442a, b)	2.5	3.2

TYPE HORIZON AND LOCALITY. Aldress Shales exposed in the bank of Ox Wood Dingle at the south-west corner of Ox Wood, just north of the Rorrington-Wotherton road (Grid Ref. SJ 290007).

DISCUSSION. *Dalmanella* is a common brachiopod in the Shelve successions. Apart from a *Dalmanella*-like species from the Mytton Flags which has been separately described, the genus is represented by a series of closely related stocks with small adult shells usually between 2 and 5 mm long ornamented by simply arranged costellae numbering 6 per mm 2 mm antero-medially of the dorsal umbo, and bearing a cardinal process with a small rounded myophore, well-developed subparallel brachiophore bases and the impressions of a bilobed ventral muscle field. These stocks occur in the Betton Beds to Aldress Shales inclusive but are very common in the Meadowtown Beds, the Spy Wood Grit and the Aldress Shales which have provided the data for the three samples listed in Tables 55 to 63.

At first sight, the stocks appear to be like the Lower Llandeilo *Dalmanella parva* Williams (1949 : 169) in the dimensions and proportions of their external and internal features. However, a sample of that species from the type locality proved to be significantly different from Shelve *Dalmanella* in a number of attributes. From all three samples *D. parva* differs in the rate of anterior expansion and in the inherently more acute divergence of its dental plates. The species further differs from the Meadowtown and Spy Wood forms in the relatively faster growth in width and, from

the Aldress sample, in the inherently greater width of the brachial valve. The Llandeilo species also differs from the Meadowtown and Aldress stocks in the shape parameters and relative growth of the cardinalia.

In contrast to these decisive specific differences, the relationship between the three Shelfe samples is much more complicated. The Meadowtown sample, herein recognized as the new species *D. salopiensis*, differs from both the Spy Wood and Aldress stocks in the more acutely divergent attitude of the dental plates; and additionally from the former in the residual length of the ventral muscle scar and the divergence of the brachiophore bases. It differs from the latter in the relative width of the brachial valve. Moreover there is also a significant difference ($p < 0.001$) in the residual shape of the brachial valve of the Aldress and Spy Wood samples. These relationships are most conveniently expressed by assuming that the Aldress and Spy Wood samples constitute two new subspecies, *D. salopiensis transversa* and *D. salopiensis gregaria* respectively.

The stratigraphic ranges of these taxa are well defined. The small number of moulds collected from the Betton Beds are indistinguishable from *D. salopiensis*. A larger sample of specimens from the Rorrington Beds, on the other hand, differs from *D. salopiensis* at least in the degree of divergence of the dental plates ($p < 0.001$), but they proved to be identical in every respect with the new Spy Wood subspecies *D. salopiensis gregaria*.

Neither *D. salopiensis* (s.l.) nor *D. parva* are like other Anglo-Welsh *Dalmanella*. *D. indica* (Whittington) appears to be most closely related, but comparisons of statistical data for that species (Williams 1963: 382-385) with those for *D. parva* and *D. salopiensis* (s.l.) reveals significant differences in a number of features including the parallel disposition of the brachiophore bases in the older species and especially in the simplicity of their ribbing patterns which are essentially: 1 \bar{a} , 1, 2 \bar{a} , 2, 3 \bar{a} , 3 \bar{b} , 3, 4 \bar{a} 1, 4 \bar{a} , 4, 4 \bar{a} °.

TABLE 55

Statistics of length (l) and maximum width (w) of n brachial valves of *Dalmanella parva* Williams (A), *D. salopiensis* sp. nov. (B), *D. salopiensis gregaria* sp. et subsp. nov. (C) and *D. salopiensis transversa* sp. et subsp. nov. (D)

	A	B	C	D
n	42	82	46	14
l mm	2.76	2.06	2.28	2.62
(var l)	(0.54)	(0.461)	(0.443)	(0.814)
\bar{w} mm	3.57	2.73	3.09	3.59
(var w)	(0.795)	(0.522)	(0.55)	(1.148)
r	0.986	0.972	0.955	0.993
$\log_e l$	0.9808	0.6721	0.7845	0.9078
(var $\log_e l$)	(0.0685)	(0.1029)	(0.0815)	(0.1119)
$\log_e w$	1.2429	0.9708	1.099	1.2364
(var $\log_e w$)	(0.0603)	(0.0675)	(0.0561)	(0.0851)
r_e	0.989	0.976	0.959	0.993
α	0.9384	0.81	0.8294	0.8723
(var α)	(0.00049)	(0.00038)	(0.00126)	(0.00088)

TABLE 56

Statistics of length (l) and thickness (th) of n pedicle valves of *Dalmanella parva* Williams (A), *D. salopiensis* sp. nov. (B), *D. salopiensis gregaria* sp. et subsp. nov. (C) and *D. salopiensis transversa* sp. et subsp. nov. (D)

	A	B	C	D
n	29	72	53	8
l mm	3.29	2.37	3.18	2.82
(var l)	(0.863)	(0.608)	(1.223)	(0.476)
th mm	1.04	0.91	1.35	1.01
(var th)	(0.092)	(0.089)	(0.0182)	(0.038)
r	0.909	0.881	0.933	0.885
a	0.3274	0.3827	0.3861	0.2839
(var a)	(0.00069)	(0.00046)	(0.00037)	(0.00291)

TABLE 57

Statistics of length (l) of n pedicle valves and length of dental plates (dl) of *Dalmanella parva* Williams (A), *D. salopiensis* sp. nov. (B), *D. salopiensis gregaria* sp. et subsp. nov. (C) and *D. salopiensis transversa* sp. et subsp. nov. (D)

	A	B	C	D
n	52	102	69	11
l mm	3.35	2.22	2.92	2.69
(var l)	(0.654)	(0.609)	(1.159)	(0.685)
dl mm	0.78	0.46	0.57	0.53
(var dl)	(0.061)	(0.025)	(0.045)	(0.026)
r	0.882	0.88	0.907	0.919
$\overline{\log_e l}$	1.1807	0.7380	1.0063	0.9446
(var $\log_e l$)	(0.0564)	(0.1168)	(0.1279)	(0.0902)
$\overline{\log_e dl}$	-0.2978	-0.8268	-0.6292	-0.6749
(var $\log_e dl$)	(0.0957)	(0.1104)	(0.13)	(0.0868)
r_e	0.888	0.887	0.913	0.925
α	1.3026	0.9724	1.0082	0.9808
(var α)	(0.00717)	(0.00201)	(0.00253)	(0.01538)

TABLE 58

Statistics of length (l) and maximum anterior divergence (w) of the dental plates in n pedicle valves of *Dalmanella parva* Williams (A), *D. salopiensis* sp. nov. (B), *D. salopiensis gregaria* sp. et subsp. nov. (C) and *D. salopiensis transversa* sp. et subsp. nov. (D)

	A	B	C	D
n	53	77	56	8
l mm	0.79	0.46	0.55	0.53
(var l)	(0.07)	(0.024)	(0.046)	(0.021)
\bar{w} mm	1.03	0.73	1.01	1.02
(var w)	(0.069)	(0.042)	(0.087)	(0.059)
r	0.951	0.805	0.879	0.901
\log_{el}	-0.2842	-0.8385	-0.6618	-0.6689
(var \log_{el})	(0.1054)	(0.1088)	(0.141)	(0.0729)
\log_{ew}	-0.0055	-0.3462	-0.0282	-0.0028
(var \log_{ew})	(0.0631)	(0.075)	(0.0812)	(0.0548)
r_e	0.955	0.813	0.886	0.907
α	0.774	0.8306	0.7588	0.8669
(var α)	(0.00103)	(0.00312)	(0.00229)	(0.02217)

TABLE 59

Statistics of length (l) of n pedicle valves and length of ventral muscle scar (sc) of *Dalmanella parva* Williams (A), *D. salopiensis* sp. nov. (B), *D. salopiensis gregaria* sp. et subsp. nov. (C) and *D. salopiensis transversa* sp. et subsp. nov. (D)

	A	B	C	D
n	44	69	61	8
l mm	3.33	2.44	3.06	2.74
(var l)	(0.608)	(0.474)	(1.099)	(0.608)
\bar{sc} mm	1.17	0.83	1.12	0.87
(var sc)	(0.084)	(0.061)	(0.198)	(0.088)
r	0.914	0.853	0.899	0.969
\log_{el}	1.1775	0.8558	1.0619	0.968
(var \log_{el})	(0.0532)	(0.0763)	(0.1112)	(0.078)
\log_{esc}	0.1317	-0.2313	0.0388	-0.1877
(var \log_{esc})	(0.0592)	(0.0858)	(0.1468)	(0.1086)
r_e	0.92	0.861	0.905	0.9713
α	1.0554	1.06	1.1487	1.1804
(var α)	(0.00408)	(0.00434)	(0.00403)	(0.01315)

TABLE 60

Statistics of length (l) of n brachial valves and length of brachiophore bases (lc) of *Dalmanella parva* Williams (A), *D. salopiensis* sp. nov. (B), *D. salopiensis gregaria* sp. et subsp. nov. (C) and *D. salopiensis transversa* sp. et subsp. nov. (D)

	A	B	C	D
n	38	121	55	22
l mm	3.11	2.18	2.56	2.48
(var l)	(0.473)	(0.517)	(0.474)	(0.811)
\bar{lc} mm	0.69	0.49	0.58	0.55
(var lc)	(0.027)	(0.025)	(0.023)	(0.027)
r	0.814	0.911	0.884	0.917
$\overline{\log_e l}$	1.1118	0.726	0.906	0.8472
(var $\log_e l$)	(0.0476)	(0.1036)	(0.0695)	(0.1236)
$\overline{\log_e lc}$	-0.3913	-0.7675	-0.5684	-0.6404
(var $\log_e lc$)	(0.0543)	(0.1005)	(0.0661)	(0.0851)
r _e	0.822	0.915	0.889	0.922
α	1.068	0.985	0.9751	0.8299
(var α)	(0.01028)	(0.00132)	(0.00376)	(0.00513)

TABLE 61

Statistics of length (l) and maximum lateral extension (w) of the brachiophore bases in n brachial valves of *Dalmanella parva* Williams (A), *D. salopiensis* sp. nov. (B), *D. salopiensis gregaria* sp. et subsp. nov. (C) and *D. salopiensis transversa* sp. et subsp. nov. (D)

	A	B	C	D
n	46	118	52	21
l mm	0.65	0.49	0.58	0.57
(var l)	(0.025)	(0.025)	(0.023)	(0.022)
\bar{w} mm	0.63	0.42	0.53	0.48
(var w)	(0.021)	(0.008)	(0.013)	(0.013)
r	0.778	0.771	0.596	0.741
$\overline{\log_e l}$	-0.4617	-0.765	-0.5718	-0.6008
(var $\log_e l$)	(0.0587)	(0.0993)	(0.0667)	(0.0656)
$\overline{\log_e w}$	-0.4811	-0.8848	-0.665	-0.7653
(var $\log_e w$)	(0.0496)	(0.0422)	(0.0452)	(0.0567)
r _e	0.787	0.781	0.604	0.75
α	0.9188	0.652	0.8228	0.9303
(var α)	(0.0073)	(0.00142)	(0.00859)	(0.01993)

TABLE 62

Statistics of length (l) of n brachial valves and length of adductor scars from umbo (sc) of *Dalmanella parva* Williams (A), *D. salopiensis* sp. nov. (B) and *D. salopiensis gregaria* sp. et subsp. nov. (C)

	A	B	C
n	13	24	22
l mm (var l)	3.45 (0.411)	2.74 (0.505)	2.74 (0.5)
\bar{sc} mm (var sc)	1.99 (0.207)	1.56 (0.149)	1.6 (0.152)
r	0.906	0.925	0.929
a (var a)	0.7104 (0.00821)	0.5439 (0.00194)	0.5518 (0.00207)

TABLE 63

The distribution of brachial valves of *Dalmanella parva* Williams (A), *D. salopiensis* sp. nov. (B), *D. salopiensis gregaria* sp. et subsp. nov. (C) and *D. salopiensis transversa* sp. et subsp. nov. (D) with 4-8 costellae per mm, 2 mm antero-medially of the dorsal umbones

	Costellae per mm				
	4	5	6	7	8
A	1	4	8	6	3
B	1	11	17	3	-
C	2	5	9	-	-
D	-	2	2	2	-

Dalmanella elementaria sp. nov.

(Pl. 16, figs. 2-8)

DIAGNOSIS. Very small, ventribiconvex, sulcate *Dalmanella* with a finely costellate ornamentation, faintly impressed bilobed ventral muscle field, slightly divergent dental plates, a short ridge-like cardinal process, subtriangular blade-like brachiophores with subparallel bases and small fulcral plates.

DESCRIPTION. Very small, ventribiconvex, subquadrate *Dalmanella* with rounded, obtuse cardinal angles; pedicle valve slightly carinate medially, one-third as deep as long; gently convex brachial valve very rarely more than 3 mm long with a mean length relative to width of 78.3% (variance 109.2) for 5 valves, median sulcus usually persistent, rounded, almost three-fifths as wide as the valve length, bounded by evenly convex lateral areas; ventral and dorsal interareas short, apsacline and anacline respectively, with an open delthyrium containing a small pedicle callist and an open notothyrium; ribbing very fine with 7 and 8 costellae per mm, 2 mm antero-medially of the umbones of 5 and 2 brachial valves respectively, first three sectors narrow with simple branching normally consisting of 1ā, 1, 2ā, 2b, 2, 3ā1, 3ā, 3, 3a°.

Teeth supported by slightly divergent dental plates extending forward for an average of 26.3% (variance 46.8) the length of 5 valves; ventral muscle field rarely and faintly impressed, apparently bilobed, with shorter median adductor scar flanked by lobate diductors.

Cardinal process consisting of a low impersistent ridge not extending to posterior margin of notothyrium, brachiophores subtriangular, blade-like with subparallel bases extending anteriorly for one-fifth the length of the valve (mean lengths and variances of 13 valves and brachiophore bases = 1.99 (0.256) and 0.41 (0.019) respectively; $r = 0.943$); sockets narrow, defined by small fulcral plates.

TYPE MATERIAL.

		length	width (mm)
HOLOTYPE	External and internal moulds of brachial valve (BB 35352a, b)	3.2	3.8

		length	width (mm)
PARATYPES	External and internal moulds of pedicle valve (BB 35353a, b)	2·5	3·5
	External and internal moulds of pedicle valve (BB 35354a, b)	1·8	—
	External and internal moulds of brachial valve (BB 35355a, b)	3·0	—
	External and internal moulds of brachial valve (BB 35356a, b)	2·0	3·0
	External and internal moulds of brachial valve (BB 35357a, b)	2·5	—

TYPE HORIZON AND LOCALITIES. Mytton Flags (Shelve Church Member): BB 35353a, b from exposures in road level north of Wood House (Grid Ref. SJ 338003), all other specimens from a trench cut 1 ft above road level near Shelve Church (Grid Ref. SO 335990).

DISCUSSION. Among the fossils recovered from the Mytton Flags, there quite commonly occur impressions of a small costellate, thin-shelled orthide which have all the essential characters expected of early enteletaceans. The combination of such features is so striking that, although there is, as yet, no proof, such as the presence of microscopic moulds of puncta, of their enteletacean affinities, they have been identified as primitive *Dalmanella*. Certainly they are strongly reminiscent of young *Dalmanella* in many respects, yet there are characters that immediately distinguish these Arenig forms from all other described *Dalmanella*. Among these are the fineness and simple arrangement of costellae and the ridge-like cardinal process which did not extend the length of the notothyrial platform nor become differentiated into myophore and shaft as in other species assigned to the genus. Not only do these features render the new species unique among known *Dalmanella* but, together with the obscurity of muscle impressions and simplicity of brachio-phore arrangement, are also the features one would expect to find in a stock that was ancestral to the more typical Ordovician *Dalmanella*. Indeed when more is known about these Arenigian stocks, they may prove to be so distinctive in the generalized nature of their cardinalia as to constitute a distinct species group within the *Dalmanella* taxon.

ONNIELLA Bancroft 1928

Onniella ostentata Williams *lepida* subsp. nov.

(Pl. 16, figs. 9-14)

DIAGNOSIS. Like *Onniella ostentata* Williams (1963: 405) but with finer costellae numbering 4 to 6 per mm at the 5 mm growth stage, shorter dental plates which grew forward more slowly and a massive bilobed cardinal process not united to the brachio-phores in adult shells.

DESCRIPTION. Small, ventribiconvex *Onniella* with obtusely rounded cardinal angles; pedicle valve 23% as deep as long with a subcarinate rounded median zone and evenly sloping to slightly concave lateral areas, brachial valve 76% as wide and 11% as deep as long with a shallow narrow to weak sulcus; ventral interarea planar apsacline, longer than anacline dorsal interarea, delthyrium and notothyrium open, pedicle callist usually well developed; radial ornamentation of costellae commonly 4 per mm, 5 mm antero-medially of dorsal umbo, external costellae poorly developed in sectors III and IV.

Teeth small trigonal, supported by dental plates extending anteriorly for 16% of the length of the pedicle valve and diverging for 49% of their length; ventral muscle field bilobed with the diductor scars extending anteriorly for 29% of the length of the pedicle valve and flanking a shorter submedial adductor scar; *vascula media* proximally divergent, remaining mantle canal system unknown.

Cardinal process consisting of linear shaft and rounded myophore in early growth stages but usually massive and medially cleft in valves more than 3 mm long; brachiophores short, acutely divergent, with bases, which may be broad and indented by a pit, extending forward for 19% of the length of the brachial valve and splaying laterally for 58% of their length; sockets well defined but without fulcral plates; adductor scars suboval, impressed on either side of median ridge and extending anteriorly for 57% of the length of the valve; mantle canal system unknown.

TYPE MATERIAL.

		length	width (mm)
HOLOTYPE	External and internal moulds of brachial valve (BB 35456a, b)	4.3	5.0
PARATYPES	External and internal moulds of pedicle valve (BB 35455a, b)	4.8	6.0
	External and internal moulds of brachial valve (BB 35457a, b)	3.0	4.0
	Internal mould of brachial valve (BB 35458)	4.0	-

TYPE HORIZON AND LOCALITY. Aldress Shales exposed in the bank of Ox Wood Dingle at the south-west corner of Ox Wood, just north of the Rorrington-Wotherton road (Grid Ref. SJ 290007).

DISCUSSION. Except for the complementary moulds of a brachial valve (BB 35572a, b) collected from the Spy Wood Grit (Pl. 16, figs. 15, 18), *Onniella* is restricted in the Shelve area to the Aldress and Whittery Shales. Although it is not very common in either formation, two small samples were available for study. They proved to be alike in every respect (Tables 64-72) and obviously represent the same species. They are however significantly different from penecontemporaneous *Onniella*, such as *O. soudleyensis* (Bancroft 1945: 210) and *O. ostentata* (Williams 1963: 405). In comparison with the former species, the Shelve *Onniella* differs in the more elongate growth of the brachial valve, the relative length and narrowness of the cardinalia and in the early development of a massive bilobed cardinal process. In respect of the last-named feature the Shelve *Onniella* is nearer *O. ostentata*

s.s. except that the cardinal process always remains discrete from the brachiophores. In other features, too, there is a noteworthy likeness between the two stocks which differ only in the relative shortness of the dental plates and the fineness of ribbing and poor development of secondary externals in sectors III and IV in the Shelve samples. In the Whittery sample, 4, 5 and 6 costellae per mm were counted 5 mm antero-medially of the umbones of 3, 1 and 1 brachial valves; while 3ā1ā)3a°, 3ĉ)3a° and 4b̄)4b° occurred in 0/4, 1/5 and 1/2 brachial valves respectively. These differences seem to be important enough to merit subspecific recognition.

TABLE 64

Statistics of length (l) and maximum width (w) of n brachial valves of *Onniella ostentata lepida* subsp. nov. from the Aldress Shales (A) and Whittery Shales (B)

	A	B
n	11	22
l mm (var l)	3.2 (0.638)	3.7 (1.149)
w̄ mm (var w)	4.12 (0.748)	4.99 (2.006)
r	0.985	0.962
$\frac{r}{\log_e l}$ (var $\log_e l$)	1.1331 (0.0604)	1.2694 (0.0804)
\log_{ew} (var \log_{ew})	1.394 (0.0429)	1.5679 (0.0775)
r _e	0.99	0.965
α (var α)	0.843 (0.00158)	0.9815 (0.00329)

TABLE 65

Statistics of length (l) and depth (th) of 12 brachial valves of *Onniella ostentata lepida* subsp. nov. from the Whittery Shales

l mm (var l)	4.22 (0.532)
th̄ mm (var th)	0.48 (0.012)
r	0.865
a (var a)	0.1527 (0.00058)

TABLE 66

Statistics of length (l) and depth (th) of 10 pedicle valves of *Onniella ostentata lepida* subsp. nov. from the Whittery Shales

l mm (var l)	3.91 (0.761)
th̄ mm (var th)	0.88 (0.068)
r	0.493
a (var a)	0.3 (0.000851)

TABLE 67

Statistics of length (l) of n pedicle valves and length of dental plates (dl) of *Onniella ostentata lepida* subsp. nov. from the Aldress Shales (A) and Whittery Shales (B)

	A	B
n	9	12
l mm (var l)	3.42 (1.017)	3.91 (1.788)
dl mm (var dl)	0.57 (0.034)	0.6 (0.061)
r	0.799	0.909
a (var a)	0.184 (0.00175)	0.185 (0.00059)

TABLE 68

Statistics of length (l) and maximum anterior divergence (w) of the dental plates in n pedicle valves of *Onniella ostentata lepida* subsp. nov. from the Aldress Shales (A) and Whittery Shales (B)

	A	B
n	9	9
l mm (var l)	0.57 (0.034)	0.52 (0.026)
w mm (var w)	1.21 (0.081)	1.01 (0.079)
r	0.858	0.877
a (var a)	1.5346 (0.0885)	1.7305 (0.09891)

TABLE 69

Statistics of length (l) of n pedicle valves and length of ventral muscle scar of *Onniella ostentata lepida* subsp. nov. from the Aldress Shales (A) and Whittery Shales (B)

	A	B
n	9	10
l mm mm (var l)	3.42 (1.017)	3.99 (1.774)
\bar{sc} mm (var sc)	1.04 (0.109)	1.11 (0.225)
r	0.915	0.882
a (var a)	0.3268 (0.00248)	0.3564 (0.00352)

TABLE 70

Statistics of length (l) of n brachial valves and length of brachiophore bases (lc) of *Onniella ostentata lepida* subsp. nov. from the Aldress Shales (A) and Whittery Shales (B)

	A	B
n	16	21
l mm (var l)	3.19 (0.652)	4.13 (0.981)
\bar{lc} mm (var lc)	0.66 (0.021)	0.69 (0.027)
r	0.681	0.913
a (var a)	0.1812 (0.00125)	0.1655 (0.00023)

TABLE 71

Statistics of length (l) and maximum lateral extension (w) of the brachiophore bases in n brachial valves of *Onniella ostentata lepida* subsp. nov. from the Aldress Shales (A) and Whittery Shales (B)

	A	B
n	16	15
l mm (var l)	0.66 (0.021)	0.66 (0.025)
w mm (var w)	1.1 (0.075)	1.19 (0.146)
r	0.803	0.967
$\overline{\log_e l}$ (var $\log_e l$)	-0.4405 (0.048)	-0.4437 (0.0566)
$\overline{\log_e w}$ (var $\log_e w$)	0.0654 (0.0597)	0.1279 (0.0977)
r_e	0.811	0.972
α (var α)	1.1157 (0.03045)	1.3139 (0.00719)

TABLE 72

Statistics of length (l) of n brachial valves and length of adductor scars (sc) of *Onniella ostentata lepida* subsp. nov. from the Address Shales (A) and Whittery Shales (B)

	A	B
n	15	10
l mm (var l)	3.2 (0.696)	4.27 (1.438)
\bar{sc} mm (var sc)	1.88 (0.235)	2.3 (0.4)
r	0.833	0.979
a (var a)	0.581 (0.00794)	0.5274 (0.00146)

Family **HARKNESSELLIDAE** Bancroft 1928

HARKNESSELLA Reed 1917

Harknessella* cf. *subplicata Bancroft

(Pl. 16, fig. 16)

An incomplete internal mould (BB 35427), about 3 mm long, from the Spy Wood Grit exposed on top of the ridge 1440 yds NNE of Rorrington bench mark 599 (Grid Ref. SJ 303018), appears to represent the immature brachial valve of a *Harknessella*. The semi-oval valve was about three-fifths as long as wide and almost one-fifth as deep as long with a well-developed median sulcus over half as wide as the valve length and gently convex lateral areas. Ribbing impressions on the mould reach almost to the cardinalia and suggest a coarsely costellate arrangement with about 4 per mm towards the anterior margin. The cardinalia consisted of a cardinal process differentiated into a stout shaft and crenulated myophore, obliquely disposed sockets defined by fulcral plates and brachiophores supported by acutely divergent bases indented submedially by deep adductor pits.

The development of adductor pits and the disposition of the brachiophore bases and fulcral plates to give the 'angulated subparallel pre-socket lines' of Bancroft (1945 : 225) indicate that the brachial valve belonged to *Harknessella*; the relative coarseness of the ribbing further suggests its close affinities with the species *H. subplicata* Bancroft (1945 : 226) from the Coston Sandstone of E. Shropshire.

HORDERLEYELLA Bancroft 1928

Horderleyella* cf. *plicata Bancroft

(Pl. 16, figs. 17, 19, 20; Pl. 17, fig. 1)

DIAGNOSIS. Small, subquadrate *Horderleyella* ornamented by 3 to 5 fasci-costellae per mm, 2 mm antero-medially of the dorsal umbo; bilobed ventral muscle scar extending anteriorly for about two-fifths the valve length; cardinal process blade-like, subparallel brachiophores extending forward for about 12% of the valve length and dorsal adductor scars impressed posteriorly in shallow hollows in the notothyrial platform.

DESCRIPTION. Small, subquadrate, ventribiconvex *Horderleyella* with cardinal angles approximating to 90°; pedicle valve carinate medially, 30% as deep as long;

brachial valve 76% as long as wide and 12% as deep as long with a strong median sulcus about two-thirds as wide as the valve length, flanked by flattened lateral areas; ventral and dorsal interareas planar, aplanar and anaplanar respectively with open delthyrium and notothyrium; radial ornamentation fascicostellate with sub-angular ribs branching internally and numbering 3, 4 and 5 per mm, 2 mm antero-medially of the umbones of 1, 2 and 1 brachial valves.

Teeth supported by divergent dental plates extending forward for 22% of the length of the valve; ventral muscle scar bilobed, about as wide as long, with sub-triangular diductor impressions extending forward for 40% the length of the valve but not enclosing the shorter median adductor scar.

Cardinal process simple, blade-like, brachiophores narrowly divergent with sub-parallel bases extending forward for 18% of the length of the brachial valve and deeply separated from well-developed fulcral plates defining splayed sockets; adductor scars lightly impressed on either side of the wide median ridge except posteriorly where they are inserted as a pair of shallow hollows into the notothyrial platform.

FIGURED MATERIAL.

	length	width (mm)
External and internal moulds of pedicle valve (BB 35431a, b)	6.0	6.5
Internal mould of brachial valve (BB 35432)	3.5	4.0
Internal mould of brachial valve (BB 35433)	4.0	—

HORIZONS AND LOCALITIES. Spy Wood Grit: BB 35431 from exposures on top of ridge 1440 yds NNE of Rorrington bench mark 599 (Grid Ref. SJ 303018): BB 35432 from exposures 1100 yds north-east of Rorrington (Grid Ref. SJ 303015). Aldress Shales: BB 35433 from exposures in bank of Ox Wood Dingle at south-west corner of Ox Wood a few yards north of the Rorrington-Wotherton road (Grid Ref. SJ 290007).

DISCUSSION. A small number of moulds of *Horderleyella*, mainly those of brachial valves, have been recovered from the Spy Wood Grit and Aldress Shales. They appear to be conspecific with *H. plicata* Bancroft (1928: 186; 1945: 236) from the Costonian and Harnagian successions of E. Shropshire, especially in the radial ornamentation and the shape and internal morphology of the brachial valve. The differentiation of the cardinal process of *H. plicata* into myophore and shaft is probably not a diagnostic feature in view of the much smaller size of the Shelve specimens. Such differences in shell size may also account for the relative delicacy of the cardinalia of *H. subcarinata* MacGregor (1961: 193) from the Upper Llandeilo of the Berwyn Hills which may also be conspecific with *H. plicata*.

In contrast to the close similarity of the brachial valves, the Shelve pedicle valves may prove to be relatively deeper and the ventral muscle scar wider and shorter, being only 79% as wide as long and 31% of the length of three pedicle valves of *H. plicata*. Larger collections, however, might indicate that these differences fall within the range of variability of *H. plicata* and, provisionally at least, the Shelve material can be identified as that species.

Orderleyella sp.

(Pl. 17, figs. 2, 3)

The external and internal moulds of an immature pedicle valve of *Orderleyella*, 2.8 mm long and 3.5 mm wide (BB 35420a, b), have been recovered from the Meadowtown Beds exposed in the lane side 370 yds north-west of Meadowtown Chapel (Grid Ref. SJ 311015).

The valve was subquadrate in outline with obtuse cardinal angles and about one-quarter as deep as long in the vicinity of a strong narrow median carina although the lateral areas are only very gently convex. The radial ornamentation was strongly fascicostellate with a count of 4 ribs per mm, 2 mm anterior of the umbo. Internally, divergent dental plates, extending anteriorly for almost one-fifth the length of the valve, formed the posterior boundaries of a subpentagonal ventral muscle scar which was about three-quarters as long as wide and extended forward for about three-tenths the valve length.

The valve cannot be placed unequivocally in any of the described species of *Orderleyella*. The relatively fine fascicostellate ornamentation is more diagnostic of the Upper Llanvirn *Orderleyella convexa* Williams (1949: 171), for which counts of 3, 4 and 5 costellae per mm have been obtained 2 mm anterior of the umbones of 1, 2 and 2 brachial valves respectively. The muscle scar, however, is very much wider than even that of *H. convexa*; and, although this difference is likely to be attributable to the immaturity of the shell, more material will have to be obtained before specific identification is merited.

REUSCHELLA Bancroft 1928***Reuschella orderleyensis* Bancroft *carinata* subsp. nov.**

(Pl. 17, figs. 4-9)

DIAGNOSIS. Subquadrate *Reuschella* with a narrowly carinate and laterally flattened pedicle valve about 23% as deep as long and a deeply sulcate brachial valve 73% as long as wide and 15% as deep as long; radial ornamentation coarsely fascicostellate with 2 or 3 ribs per mm, 10 mm anteriorly of the dorsal umbo and poorly developed external branching except in the lateral sectors; ventral muscle scar slightly bilobed and about one-third as long as the pedicle valve; brachiophore bases extending forward for 14% of the length of the brachial valve.

DESCRIPTION. Ventribiconvex, subquadrate *Reuschella* with acute cardinal angles in specimens up to 14 mm long but usually becoming obtuse in mature shells, brachial valve 73% as long as wide and 15% as deep as long with a narrowly rounded sulcus having a mean width relative to the length of 4 valves of 47% (range 39% to 55%); pedicle valve with a mean depth relative to length of 23% for 3 specimens representing the elevation of a narrow rounded carina flanked by flattened, rarely undulate lateral areas; ventral and dorsal interareas well developed, apsacline and anacline respectively with open delthyrium and notothyrium; radial ornamentation coarsely fascicostellate with counts of 2 and 3 ribs per mm, 10 mm anteriorly of the

umbones of 4 and 3 brachial valves, external branching poorly developed but progressively earlier in lateral sectors.

Teeth strong with well-developed crural fossettes supported by divergent dental plates with an average forward extension relative to the length of 6 pedicle valves of 19% (range 17% to 22%); ventral muscle scar bilobed, 83% as wide as long in 12 pedicle valves (range 72% to 104%), extending anteriorly for 34% of the length of 7 valves (range 28% to 39%) and consisting of a broad median adductor impression not enclosed by subtriangular diductor tracks; mantle canal system probably lemniscate.

Cardinal process consisting of a massive shaft with serrated ridge-like myophore embedded in a thickened notothyrial platform indented anteriorly by shallow pits for the insertion of adductor muscle bases; brachiophores divergent, blade-like defining crenulated sockets; muscle impressions unknown.

TYPE MATERIAL.

		length	width (mm)
HOLOTYPE	External and internal moulds of pedicle valve (BB 35513a, b)	13.5	17.0
PARATYPES	External and internal moulds of brachial valve (BB 35514a, b)	13.5	19.0
	Incomplete external mould of pedicle valve (BB 35515)	13.5	—
	Incomplete internal mould of brachial valve (BB 35516)	13.0	—
	Incomplete external and internal moulds of pedicle valve (BB 35517a, b)	13.5	—
	Incomplete external and internal moulds of brachial valve (BB 35518a, b)	12.5	—
	Incomplete external and internal moulds of brachial valve (BB 35519a, b)	4.0	—

HORIZON AND LOCALITIES. Whittery Shales: BB 35516 and BB 35519 from exposures about half-way down path going south to valley bottom below Marrington Farm (Grid Ref. SO 272967); the remainder from lower part of western bank of River Camlad 60 yds north-east of Marrington Farm (Grid Ref. SO 272970).

DISCUSSION. The *Reuschella* occurring in the Whittery and Hagley Shales are related to the early Caradocian *R. horderleyensis* (s.l.) which is widespread in E. Shropshire and Wales (Bancroft 1945: 239; Williams 1963: 413). However, comparisons with *R. cf. horderleyensis* and *R. horderleyensis undulata* from the Bala area (Williams 1963: 415–417) show differences exist which merit taxonomic recognition. In the outline of the shell and of the ventral muscle scar and its forward extension as well as the texture and branching of their radial ornamentation, the Shelve specimens are indistinguishable from *R. horderleyensis* and the Welsh subspecies. They do, however, differ from both taxa in being much flatter laterally and additionally from *R. horderleyensis* in the growth of the cardinalia. It seems

appropriate, therefore, to recognize the Shelve sample as a new subspecies of *R. horderleyensis*.

TABLE 73

Statistics of length (l) and maximum width (w) of 7 brachial valves of *Reuschella horderleyensis carinata* subsp. nov.

l mm (var l)	10.00 (28.5)
\bar{w} mm (var w)	13.73 (41.199)
r	0.993
$\frac{\log_e l}{\log_e w}$ (var $\log_e l$)	2.1772 (0.2506)
$\frac{\log_e w}{\log_e l}$ (var $\log_e w$)	2.5206 (0.1976)
r_e	0.995
α (var α)	0.8879 (0.00155)

TABLE 74

Statistics of length (l) and thickness (th) of 7 brachial valves of *Reuschella horderleyensis carinata* subsp. nov.

l mm (var l)	11.31 (20.841)
\bar{th} mm (var th)	1.74 (0.556)
r	0.811
a (var a)	0.1633 (0.00182)

TABLE 75

Statistics of length (l) and length of brachiophore bases (lc) in 9 brachial valves of *Reuschella horderleyensis carinata* subsp. nov.

l mm (var l)	12.69 (16.259)
lc mm (var lc)	1.81 (0.196)
r	0.883
a (var a)	0.1098 (0.00037)

TABLE 76

Statistics of length (l) and maximum lateral extension (w) of the brachiophore bases of 8 brachial valves of *Reuschella horderleyensis carinata* subsp. nov.

l mm (var l)	1.96 (0.103)
\bar{w} mm (var w)	3.99 (0.373)
r	0.771
a (var a)	1.9052 (0.24495)

Family **HETERORTHIDAE** Schuchert & Cooper 1931

HETERORTHIS Hall & Clarke 1892

Heterorthis sp.

(Pl. 17, figs. 10-14)

DIAGNOSIS. Small, semi-elliptical, plano- to concavo-convex *Heterorthis* with parallel-sided, bilobed ventral muscle scar 42% as long as the pedicle valve and a simple, median, plate-like cardinal process.

DESCRIPTION. Small, semi-elliptical, plano- to concavo-convex *Heterorthis* with cardinal angles approximating to 90° ; pedicle valve about one-tenth as deep as long, slightly carinate medially; brachial valve averaging 80% as long as wide for 5 valves, plane to gently concave with a slight median sulcus; ventral and dorsal interareas planar, apsacline and anacline respectively, delthyrium open, notothyrium covered by chilidium; radial ornamentation costellate with low rounded ribs numbering 5 per mm, 2 mm antero-medially of umbo.

Teeth small, supported by divergent dental plates; ventral muscle field parallel-sided and elongately bilobed extending forward for an average of 42% the length of 3 pedicle valves and only slightly narrower than long.

Cardinal process consisting of a simple median plate with slightly splayed posterior surface, embedded in well-developed notothyrial platform, brachiophores plate-like acutely divergent, sockets simple without bounding fulcral plates; adductor scars elongately oval impressed on either side of low median ridge, extending anteriorly for over half the valve length.

FIGURED MATERIAL.

	length	width (mm)
External and internal moulds of pedicle valve (BB 35423a, b)	4.0	—
External and internal moulds of brachial valve (BB 35424a, b)	4.5	5.5

HORIZON AND LOCALITY. Spy Wood Grit exposed 1100 yds NNE of Rorrington (Grid Ref. SJ 303015).

DISCUSSION. The *Heterorthis* collected from the Shelve area consist of only 12 valves from the Spy Wood Grit and one from the Aldress Shales. The largest of these specimens was not more than 5 mm long and, although one would expect some mature shells even in the small sample available, there is a strong possibility that the collections are moulds of young shells. Indeed the undifferentiated cardinal process and the relatively modest development of the notothyrial platform suggest that this is so; and until more is known about the age structure of such samples, infrageneric recognition is withheld. In that respect the only clue to specific affiliation is given by the relatively poor development of the lateral diductor lobes in the manner of adult *H. retrorsistria* M'Coy (Williams 1963: 420) although even that character may be merely diagnostic of immaturity.

TISSINTIA Havlíček 1970

1970 *Tissintia* Havlíček: 14.

When Havlíček proposed *Tissintia* as a new genus, he rightly emphasized its close relationship with *Heterorthis*. In consideration of the stratigraphic distribution of the only species recognized by him as belonging to the genus, he concluded that the stock bore many attributes of the prototypic heterorthisid (Havlíček 1970: 9–10). The planoconvex to ventribiconvex profile, the bilobed cardinal process and the disposition of the brachiophores in the even older *T. prototypa* confirm his identification of the changes such features underwent to give rise to the characteristics of the

Caradocian heterorthids. The reflexed costellae along the posterior edges of the shells of all heterorthids are especially interesting because well-preserved specimens from the Weston Beds show corresponding follicular embayments indenting the hinge-lines of both valves. These embayments indicate the presence, at some time or another, of backward-projecting setae. Whether functional setae persisted much within the cardinal angles is doubtful because the embayments may have been incorporated within laterally expanding hinge-lines after they had ceased to accommodate setae.

With regard to the origin of the heterorthids, the existence of so typical a *Tissintia* species as *prototypa* in the Lower Llanvirn suggests that *Paurorthis*, the earliest forms of which are not much older, may not be ancestral to the Heterorthidae as Havlíček (1970 : 16) believed. Indeed as in many other brachiopod groups, proposed lines of descent can be no more than tentative guesses until more is known of the Tremadoc–Arenig faunas.

***Tissintia prototypa* (Williams) emended A. W.**

(Pl. 17, figs. 15–19 ; Pl. 18, figs. 1–9, 11)

1949 *Dalmanella prototypa* Williams : 168.

DIAGNOSIS. Subcircular, ventribiconvex *Tissintia* with fine costellae reflexed posteriorly along the hinge-line and numbering 5 per mm, 5 mm antero-medially of the dorsal umbo ; brachiophore plates parallel with median ridge with bases extending anteriorly for 15% of the length of the brachial valve and 110% of their lateral spread ; ventral muscle field elongately bilobed, extending forward for 38% of the length of the pedicle valve.

DESCRIPTION. Subcircular, ventribiconvex to rarely planoconvex *Tissintia* with obtuse cardinal angles ; pedicle valve 21% as deep as long with an evenly convex median zone and flattened lateral areas, brachial valve 80% as long as wide and about one-tenth as deep as long or rarely planar, shallow median sulcus dying out on average 5 mm anterior of dorsal umbo (variance 0.016 for 10 valves), lateral areas flattened or slightly concave ; ventral interarea planar, apsacline, longer than anacline dorsal interarea, delthyrium and notothyrium open ; radial ornamentation fascicostellate commonly 5 per mm, 5 mm antero-medially of the dorsal umbo, external branches poorly developed in the first four sectors, costellae reflexed posterolaterally so that corresponding follicular embayments indent the internal surfaces of the hinge-lines of both valves.

Teeth small, trigonal, supported by dental plates extending anteriorly for 14% of the length of the pedicle valve and diverging for twice their length ; ventral muscle field elongately bilobed divided by a pair of fine median ridges extending forward from conspicuous pedicle callist ; adductor scars small, elongately oval, submedially situated ; diductor scars impressed anteriorly for 38% of the length of the pedicle valve but not enclosing adductors, adjustor scars impressed on the median surfaces of the dental plates ; mantle canal pattern lemniscate.

Cardinal process with bilobed myophore and long shaft on well-developed notothyrial platform passing anteriorly into median ridge; brachiophores triangular in outline, acutely divergent, brachiophore bases parallel, ankylosed to median ridge and extending anteriorly for 15% of the length of the brachial valve, sockets oblique, bounded ventrally by brachiophores but not defined laterally by fulcral plates; quadripartite adductor scars 46% as long as the valve; adjustor scars small oval, located on median ridge anterior to notothyrial platform, mantle canal pattern lemniscate.

FIGURED MATERIAL.

	length	width (mm)
Internal mould of brachial valve (BB 35305)	6.0	7.0
Internal mould of pedicle valve (BB 35306)	9.0	10.0
External mould of brachial valve (BB 35307)	7.5	9.0
External mould of brachial valve (BB 35308)	8.0	9.5
Internal mould of brachial valve (BB 35309)	14.0	16.0
Incomplete internal mould of brachial valve (BB 35310)	—	—
External and internal moulds of pedicle valve (BB 35311a, b)	14.0	20.5
External and internal moulds of pedicle valve (BB 35312a, b)	12.5	15.0
External and internal moulds of brachial valve (BB 35313a, b)	13.0	20.0
External and internal moulds of brachial valve (BB 35314a, b)	13.0	16.0
External and internal moulds of brachial valve (BB 35315a, b)	12.0	14.0

HORIZONS AND LOCALITIES. BB 35305–35310 from Lower Llanvirn ashy shales exposed in stream 240 yds west of Llwyn Bedw Farm, Llandeilo (Grid Ref. SN 653212); BB 35311, BB 35314, BB 35315 from Weston Beds exposed 210 yds south-east of road crossing Betton Dingle, Lyde (Grid Ref. SJ 317015); BB 35313 from Weston Beds at Cwm Dingle 640 yds south of Little Weston (Grid Ref. SO 294978); BB 35312 from Weston Beds in road exposure 430 yds south-west of Miner's Arms, Priestweston (Grid Ref. SO 291970).

Tissintia immatura (Williams) emended A. W.

(Pl. 18, figs. 10, 12–15; Pl. 19, figs. 1–5)

1949 *Resserella immatura* Williams: 165.

DIAGNOSIS. Subcircular, planoconvex *Tissintia* with subcarinate pedicle valve 31% as deep as long, costellae reflexed posteriorly along the hinge-line and commonly numbering 3 per mm 5 mm antero-medially of the dorsal umbo; brachiophore bases normally thickened to extend anteriorly for 17% of the length of the brachial valve and 84% of their lateral spread; ventral muscle field elongately bilobed extending forward for 38% of the length of the pedicle valve.

DESCRIPTION. Subcircular, planoconvex to more rarely ventribiconvex with obtuse cardinal angles; pedicle valve 31% as deep as long with a slightly carinate

median zone and gently convex lateral areas ; brachial valve 79% as long as wide, gently convex or more commonly planar with indistinct sulcus ; ventral interarea planar apsacline, longer than anacline dorsal interarea, delthyrium and notothyrium open ; radial ornamentation fasciostellate commonly 3 per mm, 5 mm antero-medially of the dorsal umbo, external branches poorly developed in the first three sectors, costellae reflexed postero-laterally, follicular embayments rarely indenting internal surfaces of hinge-line.

Teeth small, supported by dental plates extending anteriorly for 17% of the length of the pedicle valve and extending laterally for 150% of their length ; ventral muscle field elongately oval extending forwards for 38% of the length of the valve with splayed diductor scars almost enclosing a pair of small suboval adductor impressions separated by a low ridge ; adjustor scar located on dental plates.

Cardinal process bilobed, differentiated in adult valves into elongate shaft and expanded myophore, notothyrial platform well developed passing anteriorly into low ridge ; brachiophores triangular in outline with divergent bases extending forward for 17% of the length of the valve, becoming massive in adult valves so that they are, on average, only 84% as long as their lateral spread ; oblique sockets not bounded laterally by fulcral plates ; adductor scars quadripartite extending forward for half the length of the valve.

FIGURED MATERIAL.

	length	width (mm)
External and internal moulds of pedicle valve (BB 35474a, b)	8.0	—
External and internal moulds of brachial valve (BB 35475a, b)	4.0	5.0
External and internal moulds of pedicle valve (BB 35476a, b)	9.0	12.0
Incomplete external and internal moulds of brachial valve (BB 35477a, b)	14.0	—
External and internal moulds of brachial valve (BB 35478a, b)	10.0	12.0
Internal mould of pedicle valve (BB 35479)	11.5	—

HORIZON AND LOCALITIES. Meadowtown Beds: BB 35474, 35475 from loose blocks on rough ground 100 yds south-east of Minicop Farm (Grid Ref. SJ 315018) ; BB 35478 from Bed B in measured section in Meadowtown Quarry (Grid Ref. SJ 312012) ; BB 35479 from Quinton's Quarry in the field 200 yds north-east of Meadowtown Chapel (Grid Ref. SJ 312013). BB 35476, 35477 from exposures in a ploughed field along the strike of Betton Beds occurring 180 yds south-west of a well in the lane-side from Meadowtown to Castle Ring (Grid Ref. SJ 310009).

DISCUSSION. *Tissintia prototypa* was first described from the upper part of the *Didymograptus bifidus* shales of the Llandeilo district (Williams 1953: 180) and is now known from W. Wales and Builth as well as Shropshire, where it occurs abundantly in the Llanvirn Weston Beds. A good sample from the Weston Beds has been statistically compared with a topotypic assemblage. The comparison shows (Tables 77-85) that there is no difference between the two samples in parameters of the shape of the shell, the disposition and size of internal features, or in the radial ornamentation except for a marginally significant delay in the differentiation of the

3ālā costella. This distinction is not considered important enough to merit systematic recognition so that the species may be regarded as a noteworthy homogeneous, short-ranging stock especially characteristic of the Lower Llanvirn of Britain.

The Llandeilo species *T. immatura* from the Meadowtown Beds is more closely related to *T. prototypa* than was originally thought when the two species were erected. Both species are similar in dorsal outline and the relative sizes of internal features. They differ however in a number of important characters. In *T. immatura* the ribbing is significantly coarser ($p > 0.001$) with a suggestion that externally branching ribs are more commonly developed in Sector IV; the growth in relative depth of the pedicle valve is faster ($p < 0.001$); and the lateral spread of the brachiophore bases is significantly greater ($0.05 > p > 0.02$). This last difference reflects not only the more divergent disposition of the brachiophore bases in *T. immatura* but also their excessive thickening by secondary shell accretion in mature stages of growth.

A small sample of *Tissintia* from the Betton Beds of Shelve, although stratigraphically intermediate between the two species, was identical with *T. prototypa* in the key differences. Rib counts per mm, 5 mm antero-medially of the umbones of 2, 3 and 5 brachial valves were 4, 5 and 6; the basic statistics for length (l) and depth (th) of 11 pedicle valves were: \bar{l} (var l) = 7.68 (3.872), \bar{th} (var th) = 1.53 (0.27) and $r = 0.909$; and for the length (l) and maximum lateral extension (w) of the brachiophore bases in 11 brachial valves they were: \bar{l} (var l) = 1.15 (0.137), \bar{w} (var w) = 1.11 (0.179) and $r = 0.936$. Allometry prevailed in both the deepening of the pedicle valve and the extension of the brachiophores, but neither growth rates nor shape parameters differed significantly from those of *T. prototypa*.

The only other species assigned to the genus is *T. convergens* from the Llandeilo of Morocco (Havlíček 1971: 51), which appears to differ from the British species, at least, in being relatively more transverse and in possessing smaller brachiophores and longer, more flabellate ventral muscle scars.

TABLE 77

Statistics of length (l) and length of brachiophore bases (lc) in n brachial valves of *Tissintia prototypa* (Williams) from the Weston Beds (A) and the Lower Llanvirn of Llandeilo (B), and of *T. immatura* (Williams) from the Meadowtown Beds (C)

	A	B	C
n	21	55	64
\bar{l} mm (var l)	8.87 (14.326)	8.59 (4.4)	6.03 (14.756)
\bar{lc} mm (var lc)	1.4 (0.303)	1.17 (0.054)	1.05 (0.361)
r	0.941	0.871	0.966
$\overline{\log_e l}$ (var $\log_e l$)	2.0986 (0.1674)	2.122 (0.0578)	1.6267 (0.3404)
$\overline{\log_e lc}$ (var $\log_e lc$)	0.2685 (0.1426)	0.1384 (0.0387)	-0.0903 (0.2824)
r_e	0.944	0.875	0.972
α (var α)	0.9229 (0.00485)	0.8182 (0.00295)	0.9108 (0.00075)

TABLE 78

Statistics of length (l) and length of adductor scars from umbo (sc) in n brachial valves of *Tissintia prototypa* (Williams) from the Weston Beds (A) and the Lower Llanvirn of Llandeilo (B), and of *T. immatura* (Williams) from the Meadowtown Beds (C)

	A	B	C
n	12	6	34
l mm (var l)	10.43 (8.345)	11.18 (3.402)	8.08 (15.198)
\bar{sc} mm (var sc)	4.77 (1.599)	5.13 (0.926)	4.04 (2.818)
r	0.935	0.979	0.984
a (var a)	0.4377 (0.00242)	0.5217 (0.0028)	0.4306 (0.00018)

TABLE 79

Statistics of length (l) and maximum width (w) of n brachial valves of *Tissintia prototypa* (Williams) from the Weston Beds (A) and the Lower Llanvirn of Llandeilo (B), and of *T. immatura* (Williams) from the Meadowtown Beds (C)

	A	B	C
n	27	54	52
l mm (var l)	6.92 (18.479)	7.62 (9.47)	5.66 (11.628)
\bar{w} mm (var w)	9.01 (29.887)	9.25 (10.229)	7.11 (15.49)
r	0.987	0.903	0.99
$\overline{\log_e l}$ (var $\log_e l$)	1.771 (0.3265)	1.9559 (0.1508)	1.5786 (0.3097)
$\overline{\log_e w}$ (var $\log_e w$)	2.0424 (0.3131)	2.1678 (0.1129)	1.8275 (0.2674)
r_e	0.989	0.91	0.992
α (var α)	0.9793 (0.00464)	0.8653 (0.00247)	0.9292 (0.00027)

TABLE 80

Statistics of length (l) and thickness (th) of n pedicle valves of *Tissintia prototypa* (Williams) from the Weston Beds (A) and the Lower Llanvirn of Llandeilo (B), and of *T. immatura* (Williams) from the Meadowtown Beds (C)

	A	B	C
n	14	31	49
l mm (var l)	10.81 (18.219)	7.88 (3.719)	7.18 (12.06)
th mm (var th)	2.59 (1.299)	1.45 (0.17)	2.19 (0.925)
r	0.895	0.800	0.932
a (var a)	0.267 (0.00118)	0.2138 (0.00057)	0.277 (0.00022)

TABLE 81

Statistics of length (l) and length of dental plates (dl) in n pedicle valves of *Tissintia prototypa* (Williams) from the Weston Beds (A) and the Lower Llanvirn of Llandeilo (B), and of *T. immatura* (Williams) from the Meadowtown Beds (C)

	A	B	C
n	21	27	53
l mm (var l)	11.45 (9.102)	8.36 (3.282)	6.92 (14.129)
dl mm (var dl)	1.68 (0.328)	1.06 (0.055)	1.18 (0.341)
r	0.909	0.624	0.946
$\overline{\log_e l}$ (var $\log_e l$)	2.4044 (0.0671)	2.0999 (0.0461)	1.8049 (0.2586)
$\overline{\log_e dl}$ (var $\log_e dl$)	0.4614 (0.1103)	0.0297 (0.0484)	0.0522 (0.2205)
r_e	0.914	0.627	0.952
α (var α)	1.2822 (0.0143)	1.0246 (0.02548)	0.9234 (0.00157)

TABLE 82

Statistics of length (l) and length of ventral muscle scar (sc) in n pedicle valves of *Tissintia prototypa* (Williams) from the Weston Beds (A) and the Lower Llanvirn of Llandeilo (B), and of *T. immatura* (Williams) from the Meadowtown Beds (C)

	A	B	C
n	20	17	43
l mm (var l)	11.45 (9.581)	9.51 (2.327)	7.5 (13.902)
sc mm (var sc)	4.11 (1.881)	3.31 (0.432)	2.84 (2.991)
r	0.934	0.729	0.96
$\frac{r}{\log_e l}$ (var $\log_e l$)	2.4023 (0.0706)	2.2392 (0.0255)	1.9048 (0.2208)
$\log_e sc$ (var $\log_e sc$)	1.3606 (0.1056)	1.1762 (0.0389)	0.8848 (0.316)
r _e	0.937	0.73	0.967
α (var α)	1.2231 (0.01008)	1.2351 (0.04747)	1.1963 (0.00229)

TABLE 83

Statistics of length (l) and maximum lateral extension (w) of the brachiophore bases of n brachial valves of *Tissintia prototypa* (Williams) from the Lower Llanvirn of Llandeilo (A) and *T. immatura* (Williams) from the Meadowtown Beds (B)

	A	B
n	61	67
l mm (var l)	1.22 (0.069)	1.09 (0.382)
w mm (var w)	1.1 (0.065)	1.29 (0.441)
r	0.895	0.927
$\frac{r}{\log_e l}$ (var $\log_e l$)	0.1729 (0.0457)	-0.0527 (0.2783)
$\log_e w$ (var $\log_e w$)	0.0707 (0.052)	0.1372 (0.235)
r _e	0.9	0.935
α (var α)	1.0674 (0.00367)	0.919 (0.00163)

TABLE 84

Proportions of the earlier insertion of 10 costellae relative to 10 others (with the number of brachial valves in which both costellae originated at the same growth stage in brackets) for *Tissintia prototypa* (Williams) from the Weston Beds (A) and the lower Llanvirn of Llandeilo (B) and for *Tissintia immatura* (Williams) from the Meadowtown Beds (C)

	A	B	C
1ā1) 1b	1/7 (1)	0/6 (2)	1/4 (2)
1b) 1a°	8/8	10/13 (1)	5/9 (1)
2b) 2a°	9/9	15/17 (1)	11/12 (2)
2c) 2a°	1/3	2/11 (3)	0/4 (1)
2ā1) 2b	1/3 (5)	0/5 (7)	2/8 (3)
3ā1a) 3a°	1/4 (4)	0/14	3/14 (1)
3c) 3a°	2/7 (2)	0/15	1/12 (1)
3ā1ā) 2a°	8/8	3/10 (2)	9/12
4b) 4b°	8/8	3/3 (2)	1/4 (3)
4ā1°) 4b1	0/2	1/3	2/3

TABLE 85

The distribution of brachial valves of *Tissintia prototypa* (Williams) from the Weston Beds (A) and the Lower Llanvirn of Llandeilo (B), and of *Tissintia immatura* (Williams) from the Meadowtown Beds (C), with 3-6 costellae per mm, 5mm antero-medially of the dorsal umbones

	costellae per mm			
	3	4	5	6
A	1	4	11	0
B	2	18	27	4
C	12	6	1	0

Family **LINOPORELLIDAE** Schuchert & Cooper 1931

SALOPIA Williams 1955

Salopia cf. *salteri* (Davidson)

(Pl. 19, figs. 10, 11)

An incomplete mould of a brachial valve (BB 35426a, b) is the only record of *Salopia* in Spy Wood Grit. The specimen, which was recovered from the outcrops 1100 yds NNE of Rorrington (Grid Ref. SJ 303015), indicates that the convex and gently sulcate valve was about 5 mm long and was ornamented by fine multicostellae with a density of 6 per mm at the antero-medial margin. Although the mould is broken posteriorly it is possible to determine that the cardinalia included a pair of widely placed brachiophore bases bounding a low notothyrial platform supporting the linear shaft of a cardinal process. The notothyrial platform passes anteriorly into a broad median ridge with adductor impressions on either side.

In respect of its preserved features, the valve is indistinguishable from that of *Salopia salteri* (Davidson) as illustrated in Whittington & Williams (1955, pl. 38, figs. 45, 46) and provisionally, at least, may be assigned to that species.

Salopia sp.

(Pl. 19, figs. 6-9)

In contrast to the Spy Wood representative of *Salopia*, the three congeneric moulds from the Whittery Shales, exposed in Whittery Quarry (BB 35428a, b, BB 35429a, b) at the south end of Whittery Wood near Chirbury (Grid Ref. SO 275981) and in the stream (BB 35430a, b) at the north end of Spring Coppice 865 yds south-east of Hockleton Bridge (Grid Ref. SO 279997), are less decisively related to *S. salteri*. The two pedicle valves represented by the moulds BB 35429 and 35430 were strongly convex, about one-quarter as deep as long, rectimarginate, with a high apsacline interarea. The widely placed dental plates were more nearly parallel in the smaller valve than the larger although the muscle fields of both, consisting of a pair of lobate diductor scars flanking a narrow median adductor track, were impressed beyond the limits of the dental plates and extended forwards for up to one-third the length of the valve. The ribbing was too poorly preserved on external moulds to indicate more than a finely costellate condition. However, costellae ornamenting the brachial valve (BB 35428), although occurring with a density comparable with that of

S. salteri of 5 per mm, 5 mm antero-medially of the umbo, are sharper and less uniformly multicostellate. This difference is the only important one observed because the apparent greater convexity and sulcation are attributable to post-diagenetic deformation of the specimen. When more is known about ribbing variation in *Salopia* the difference may prove to have no systematic status; meanwhile it seems advisable not to allocate the specimens to any described species.

Suborder CLITAMBONITIDINA Öpik 1934

Superfamily GONAMBONITACEA Schuchert & Cooper 1931

Family GONAMBONITIDAE Schuchert & Cooper 1931

Subfamily ANOMALORTHINAE Ulrich & Cooper 1936

OSLOGONITES Öpik 1939

Oslogonites ? sp.

(Pl. 19, figs. 12, 13)

An external and incomplete internal mould of a brachial valve (BB 35326a, b) about 2 mm long and 3.5 mm wide, from the Mytton Flags exposed along the side of the footpath at road level, 1100 yds NNW of Wood House (Grid Ref. SJ 338003), is believed to represent the remains of an immature specimen of *Oslogonites* Öpik. The valve was semicircular in outline and evenly concave in profile with acute cardinal angles. It was ornamented by intercalated costellae, numbering 6 per mm anteriorly, with every fourth or fifth thickened to delineate a series of sectors in an unequally parvicostellate fashion. Enough of the internal mould is preserved to show that the socket ridges were acutely disposed to the hinge-line to define narrow sockets and joined medially in a small ridge which was not differentiated into a cardinal process. There was no notothyrial platform nor median ridge, but a pair of curved septa occurred in the area normally occupied by adductor scars.

The concavity of the brachial valve and the unequally parvicostellate nature of its radial ornamentation suggest either a strophomenidine or a clitambonitidine affinity. However, the disposition of the socket ridges favour its identification as a clitambonitidine; and since the anomalous lack of a notothyrial platform may be attributable to the immaturity of the valve, the specimen is best assigned to *Oslogonites*. In fact the Shelve brachial valve probably resembled that of *Oslogonites costellatus* (Öpik 1939: 134) from the Arenigian *expansus* Shale of Norway except that it was more concave and its parvicostellate ornamentation more strongly differentiated into sectors.

Family KULLERVOIDAE Öpik 1934

KULLERVO Öpik 1932

Kullervo sp.

(Pl. 19, figs. 14, 15)

The only kullervoidid represented in the Whittard collection consists of a fractured internal mould and an incomplete complementary external mould of a

pedicle valve (BB 35340a, b) from the Meadowtown Beds exposed in the lane to Waitchley 140 yds north of Meadowtown Chapel (Grid Ref. SJ 311014). These meagre fragments indicate that the valve was about 4.0 mm long, 5.5 mm wide and 1.5 mm deep with a high apsacline interarea, slightly acute cardinal angles and a faint antero-medial sulcus. Radial ornamentation consisted of about 20 rounded costae and a few costellae arising by branching with 3 ribs per mm at the antero-lateral margin. The ribs and interspaces were crossed by strong, outwardly deflected lamellae. This concentric ornamentation is regularly arranged with a density of 4 lamellae per mm at the valve margin and breaks the continuity of the ribs. The valve interior was dominated by a spondylium supported by a median septum extending forward for 1.5 mm.

Consideration of the valve profile and outline, ornamentation, and the nature of the spondylial support, suggests that the specimen is best assigned to *Kullervo*. Indeed, sufficient radial ornamentation is preserved to prompt comparison with one of the earliest recorded species, *K. panderi* (Öpik 1934:164) from the C₂ horizon of Estonia, because there is no strong differentiation between the postero-lateral and medial sectors of radial ornamentation as in later species. However, until more material is obtained to assess the validity of this comparison, only a generic identification is appropriate.

Suborder TRIPLESIIDINA Moore 1952

Superfamily TRIPLESIIACEA Schuchert 1913

Family TRIPLESIIDAE Schuchert 1913

TRIPLESIA Hall 1859

Triplesia sp.

(Pl. 19, fig. 16)

An incomplete internal mould (BB 35408), with fragments of the shell adhering, of the genus *Triplesia* have been recovered from the Whittery Shales exposed in the stream at the north end of Spring Coppice, 865 yds south-east of Hockleton Bridge (Grid Ref. SO 279997). The mould is that of a pedicle valve which was 12.5 mm long, 10 mm wide and 2.5 mm deep laterally. Its outline was subquadrate with rounded obtuse cardinal angles and it was indented medially by a strong flat-bottomed sulcus, about half as wide as the maximum width of the valve, which was sharply bent into a right angle to project dorsally as a tongue about one-third as long as the ventral length of the valve. The apsacline interarea, which was curved, bore a medially folded pseudodeltidium, and the external surface bore only fine overlapping lamellae numbering about 14 per mm anteriorly. Internally the dental plates were acutely divergent, extending forward for about one-fifth the length of the valve, while the diductor scars were lightly impressed for over half the length of the valve on either side of a low median ridge.

The Whittery *Triplesia* with its flat-bottomed sulcus and sharply bent, dorsally projecting tongue is immediately distinguishable from penecontemporaneous

European and African species, such as *T. simplex* from the Ktaoua Formation of Morocco (Havlíček 1971 : 66) and *T. deformata* (Barrande 1879) from the Zahofany Formation of Czechoslovakia (Havlíček 1950 : 89), with their gently rounded non-geniculate sulci. It is, however, similar to *T. subcarinata* (Cooper 1956 : 538) from the Lebanon Formation of Tennessee ; but systematic consideration of this apparent relationship must await the information provided by more material.

BICUSPINA Havlíček 1950

Bicuspina subquadrata sp. nov.

(Pl. 19, figs. 17-19 ; Pl. 20, figs. 1, 2)

DIAGNOSIS. Subquadrate *Bicuspina*, with a dorsal fold about 44% as wide as the brachial valve length, usually bearing a median costa which rarely branches within 5 mm of the umbo, finely lamellose with 7 lamellae developed between 5 and 6 mm antero-medially of the umbo.

DESCRIPTION. Medium-sized, dorsibiconvex, subquadrate *Bicuspina* with rounded, obtuse cardinal angles ; pedicle valve 25% as deep as long with flat-bottomed median sulcus bounded by parallel sides and evenly convex flanks ; brachial valve 65% as long as wide and 37% as deep as long with a strong median fold 44% as wide as the valve is long ; ventral interarea curved apsacline, pseudodeltidium with narrow median fold, dorsal interarea vestigial ; radial ornamentation of rounded ribs with a mean wavelength of 0.44 mm (variance 0.02), 5 mm anterior of the umbones of 15 brachial valves—a median costa (flanked by 2 laterals) occurs on folds of 11 out of 16 brachial valves and bifurcates within 5 mm of the umbo in only 1 valve—9 to 15 ribs occur on the flanks of brachial valves between 5 and 7.5 mm long ; concentric ornamentation of delicate overlapping lamellae with 6 or 7 occurring between 5 and 6 mm anteriorly of the umbones of 2 and 7 brachial valves respectively.

Pedicle tube relatively short, averaging 12% the length of the pedicle valve and with slightly curved pedicle passage ; rounded teeth supported by acutely divergent dental plates 60% as long as their anterior separation and extending forward for 17% of the length of the valve ; suboval muscle field well impressed in late adult stages of growth only, extending forward for 48% of the length of the pedicle valve and consisting of a short median adductor and a pair of ventral adjustors situated on either side of the internal opening of the pedicle tube, which is flanked by long diductor scars.

Cardinalia consisting of forked, posteriorly curving cardinal process, and short, acutely divergent, pointed brachiophores ; sockets disposed parallel to the hinge-line, extending laterally for 33% of the length of the valve, not restricted distally by ridges of secondary shell.

TYPE MATERIAL.

		length	width (mm)
HOLOTYPE	Internal and incomplete external moulds of pedicle valve (BB 35480a, b)	18.0	20.0

		length	width (mm)
PARATYPES	External and internal moulds of brachial valve (BB 35481a, b)	11.5	—
	External and incomplete internal moulds of pedicle valve (BB 35482a, b)	12.0	16.5
	Internal mould of brachial valve (BB 35483)	14.5	22.5

HORIZON AND LOCALITIES. Whittery Shales: BB 35480 from Tuffaceous Shale exposed in the lower part of the western bank of the River Camlad 60 yds north-east of Marrington Farm (Grid Ref. SO 272970); other specimens from Whittery Quarry at the south end of Whittery Wood near Chirbury (Grid Ref. SO 275981).

Bicuspina modesta sp. nov.

(Pl. 20, figs. 3-8)

DIAGNOSIS. Subquadrate *Bicuspina* with a dorsal fold about half as wide as the valve length, commonly bearing a median costa which usually branches within 5 mm of umbo, lamellose with 5 lamellae developed between 5 and 6 mm antero-medially.

DESCRIPTION. Small, biconvex, subquadrate *Bicuspina* with obtuse or, more rarely, orthogonal cardinal angles; pedicle valve 24% as deep as long with a flat-bottomed median sulcus bounded by parallel sides and evenly convex flanks, brachial valve 75% as long as wide and 35% as deep as long with a splayed median fold 50% as wide as the valve is long; ventral interarea curved apsaline, pseudodeltidium with narrow median fold, dorsal interarea vestigial; radial ornamentation of rounded ribs with a mean wavelength of 0.5 mm (variance 0.08), 5 mm anterior of the umbones of 27 brachial valves, median costa (flanked by 2 laterals) occurs on folds of 34 out of 37 brachial valves and bifurcates within 5 mm of the umbones of 19 valves; 11 to 17 ribs occur on the flanks of brachial valves between 5 and 7.5 mm long; concentric ornamentation of overlapping lamellae with 4 or 5 occurring between 5 and 6 mm anteriorly of the umbones of 2 brachial valves in each case.

Pedicle tube and passage averaging 11% of the length of the pedicle valve; small teeth supported by acutely divergent dental plates extending forward for 68% of their anterior separation and 15% as long as the valve; muscle field poorly impressed extending forward for 55% of the length of the pedicle valve.

Cardinalia consisting of forked posteriorly curving cardinal process and short, acutely divergent, pointed brachiophores; sockets disposed parallel to the hinge-line extending laterally for 26% of the length of the valve, usually defined distally by ridges of secondary shell.

TYPE MATERIAL.

		length	width (mm)
HOLOTYPE	External and internal moulds of pedicle valve (BB 35510a, b)	10.0	12.0
PARATYPES	External and internal moulds of brachial valve (BB 35511a, b)	7.0	8.5
	External and internal moulds of brachial valve (BB 35512a, b)	9.5	11.5

HORIZON AND LOCALITY. Spy Wood Grit exposed 1100 yds north-east of Rorrington (Grid Ref. SJ 303015).

DISCUSSION. *Bicuspina* is well represented in the Spy Wood Grit and the Whittery Shales by two closely related forms which are, nonetheless, distinguishable in the relative size of the median fold and sulcus and in ornamentation. As comparison of growth axes demonstrated (Tables 86-93), the two species are alike in the outline and depth of the valves as well as in the relative growth of dental plates and cardinalia. The dorsal fold of *B. subquadrata*, however, is relatively narrower than that of *B. modesta*, and a *t*-test indicates that the difference was maintained during shell growth at a significant level ($0.01 > p > 0.001$). This difference may have influenced the incidence of ribs on the folds because a median costa is more frequently absent or, if present, more likely to have bifurcated in later stages of shell growth in *B. subquadrata* than in *B. modesta*. Concentric lamellae of the former species are also more delicate and more closely spaced than those of *B. modesta*.

The Shelfe species may be ancestral to *B. spiriferoides* (M'Coy) which is widely distributed in late Soudleyan and Longvillian rocks of Shropshire and N. Wales. Lack of suitable material has precluded study of the variability of the radial ornament and especially the development of a dorsal median costa (Williams 1963: 426). *B. spiriferoides*, however, is distinct in its relatively greater width, its rectangular to acute cardinal angles, and its relatively long dental plates and ventral muscle field.

The *Bicuspina* described by Havlíček (1950: 88-90) from the late Llandeilian-early Caradocian (Chrústenice and Lodeňice substages) rocks of Czechoslovakia also differ in a number of respects but especially in the relative coarseness of ribbing in *B. cava* (Barrande) and the lack of fold and sulcus in *B. multicostellata* Havlíček.

TABLE 86

Statistics of length (l) and maximum width (w) of n brachial valves of *Bicuspina subquadrata* sp. nov. (A) and *Bicuspina modesta* sp. nov. (B)

	A	B
n	7	34
l mm (var l)	9.10 (10.037)	6.55 (8.024)
w mm (var w)	13.94 (19.843)	8.70 (13.113)
r	0.986	0.966
a (var a)	1.4061 (0.01130)	1.2783 (0.03384)

TABLE 87

Statistics of length (l) and maximum depth (th) of n brachial valves of *Bicuspina subquadrata* sp. nov. (A) and *Bicuspina modesta* sp. nov. (B)

	A	B
n	10	33
l mm (var l)	8.13 (4.447)	6.70 (7.165)
th mm (var th)	3.00 (1.315)	2.36 (1.033)
r	0.916	0.869
a (var a)	0.5439 (0.00595)	0.3797 (0.00114)

TABLE 88

Statistics of length (l) and maximum width of folds (f) in n brachial valves of *Bicuspina subquadrata* sp. nov. (A) and *Bicuspina modesta* sp. nov. (B)

	A	B
n	10	36
l mm (var l)	8.55 (5.660)	6.41 (3.757)
f mm (var f)	3.79 (2.465)	3.18 (0.747)
r	0.9537	0.794
$\frac{r}{\log_e l}$ (var $\log_e l$)	2.1086 (0.0746)	1.8143 (0.0875)
$\frac{r}{\log_e f}$ (var $\log_e f$)	1.2533 (0.1583)	1.1205 (0.0714)
r_e	0.958	0.8000
α (var α)	1.4567 (0.02400)	0.9033 (0.00886)

TABLE 89

Statistics of length (l) and maximum depth (th) of n pedicle valves of *Bicuspina subquadrata* sp. nov. (A) and *Bicuspina modesta* sp. nov. (B)

	A	B
n	13	19
l mm (var l)	9.82 (14.945)	7.12 (2.352)
th mm (var th)	2.46 (1.382)	1.68 (0.335)
r	0.949	0.807
a (var a)	0.3042 (0.00083)	0.3774 (0.00292)

TABLE 90

Statistics of length (l) and length of dental plates (dl) in n pedicle valves of *Bicuspina subquadrata* sp. nov. (A) and *Bicuspina modesta* sp. nov. (B)

	A	B
n	12	32
l mm (var l)	10.47 (13.713)	7.33 (3.207)
dl mm (var dl)	1.77 (0.858)	1.13 (0.092)
r	0.925	0.524
$\frac{r}{\log_e l}$ (var $\log_e l$)	2.2903 (0.1178)	1.9637 (0.0578)
$\frac{r}{\log_e dl}$ (var $\log_e dl$)	0.4476 (0.2430)	0.0916 (0.0690)
r_e	0.936	0.533
α (var α)	1.4363 (0.02974)	1.0927 (0.02640)

TABLE 91

Statistics of length (dl) and anterior separation (dw) of dental plates in n pedicle valves of *Bicuspina subquadrata* sp. nov. (A) and *Bicuspina modesta* sp. nov. (B)

	A	B
n	12	33
dl mm (var dl)	1.59 (0.444)	1.15 (0.076)
dw mm (var dw)	2.66 (1.284)	1.68 (0.122)
r	0.905	0.647
a (var a)	1.7000 (0.05245)	1.2679 (0.03014)

TABLE 92

Statistics of length (l) and length (tl) of pedicle tubes in n pedicle valves of *Bicuspina subquadrata* sp. nov. (A) and *Bicuspina modesta* sp. nov. (B)

	A	B
n	10	24
\bar{l} mm (var l)	11.39 (11.677)	7.54 (3.423)
\overline{tl} mm (var tl)	1.41 (0.668)	0.85 (0.215)
r	0.865	0.434
$\overline{\log_e l}$ (var $\log_e l$)	2.3897 (0.0862)	1.9907 (0.0584)
$\overline{\log_e tl}$ (var $\log_e tl$)	0.1988 (0.2896)	0.2927 (0.2603)
r_e	0.887	0.457
α (var α)	1.8330 (0.10570)	2.1112 (0.16440)

TABLE 93

Statistics of length (l) and lateral extension of sockets (br) in n brachial valves of *Bicuspina subquadrata* sp. nov. (A) and *Bicuspina modesta* sp. nov. (B)

	A	B
n	7	17
\bar{l} mm (var l)	10.21 (10.858)	7.46 (8.487)
\overline{br} mm (var br)	3.37 (0.930)	1.95 (0.596)
r	0.887	0.905
a (var a)	0.2927 (0.00365)	0.2650 (0.00084)

CAEROPLECIA gen. nov.

NAME. A triplésiid with a concentric ornament like the end threads (Gk. *καίρος*) in a loom.

DIAGNOSIS. Subcircular, dorsibiconvex, uniplicate triplésiids with a strongly convex brachial valve and a gently convex to flat pedicle valve, bearing respectively a flat-topped fold and complementary sulcus arising anterior of the umbo; ventral interarea short, apsacline, pseudodeltidium narrowly folded medially, foramen supra-apical, dorsal interarea linear; radial ornamentation of coarse costae and branching costellae originating during later stages of shell growth, concentric ornamentation of delicate rounded ridges (fila).

Ventral interior with variably developed pedicle tube, small teeth supported by short acutely divergent dental plates, muscle scars broadly bilobed with low median ridge dividing narrow adductor band; mantle canal pattern unknown.

Dorsal interior with short forked cardinal process, divergent rod-like brachio-phores, and small oblique sockets; fine median ridge dividing quadripartite adductor scars with anterior pair larger than posterior; mantle canal pattern unknown.

TYPE SPECIES. *Caeroplecia plicata* sp. nov. from the Whittery Shales, Shropshire.

DISCUSSION. The new genus is unique among triplésiaceans in being concentrically ornamented by fine, rounded ridges instead of overlapping lamellae. The delayed development of radial ornamentation, the subcircular outline and the flattish pedicle valve together also distinguish *Caeroplecia* from all other triplésiid genera.

Caeroplecia plicata sp. nov.

(Pl. 20, figs. 14-16; Pl. 21, figs. 1-6, 8; Text-fig. 9)

DIAGNOSIS. Subcircular *Caeroplecia* with a brachial valve about 80% as long as wide, and low rounded costellae with a wavelength of 0.6 mm, 5 mm antero-medially of the dorsal umbo, first appearing on shells more than 3 mm long and commonly numbering 6 on the fold and 5 to 9 on the lateral slopes.

DESCRIPTION. Dorsibiconvex, subcircular *Caeroplecia* with obtusely rounded cardinal angles; pedicle valve 18% as deep as long with flat-bottomed shallow median sulcus and flattened lateral slopes; brachial valve 80% as long as wide and 30% as deep as long with flat median fold, 43% as wide as the length of the valve, originating 2.5 mm anterior of umbo (average for 4 brachial valves); ventral interarea short apsacline, pseudodeltidium narrowly folded medially, dorsal interarea linear; concentric ornamentation of 8 to 10 fila per mm between 5 and 6 mm anterior of dorsal umbo, radial ornamentation not developed on immature shells up to an average of 3.2 mm long (variance 2.233 for 10 brachial valves), thereafter rounded costae and implanted costellae occur, having a mean wavelength of 0.63 mm, 5 mm anterior of the umbones of 4 brachial valves with 5, 6, 7 and 8 ribs on the folds of 2, 3, 1 and 2 brachial valves between 9 and 12 mm long and 5 to 9 ribs on the lateral slopes.

Pedicle tube weakly developed, less than 7% as long as the valve; teeth supported by acutely divergent dental plates extending anteriorly for a mean of 11.8% of the length of 6 pedicle valves (variance 5.86); muscle field faintly impressed but broadly bilobed, extending anteriorly for about one-third the length of the valve, with splayed diductor scars not enclosing a narrow parallel-sided adductor track divided by a fine median ridge.

Cardinalia consisting of slightly recurved forked cardinal process, short brachio-phores and obliquely placed sockets arranged along the hinge-line for an average of 24% of the length of 5 brachial valves; adductor scars quadripartite, lightly impressed about a fine median ridge.

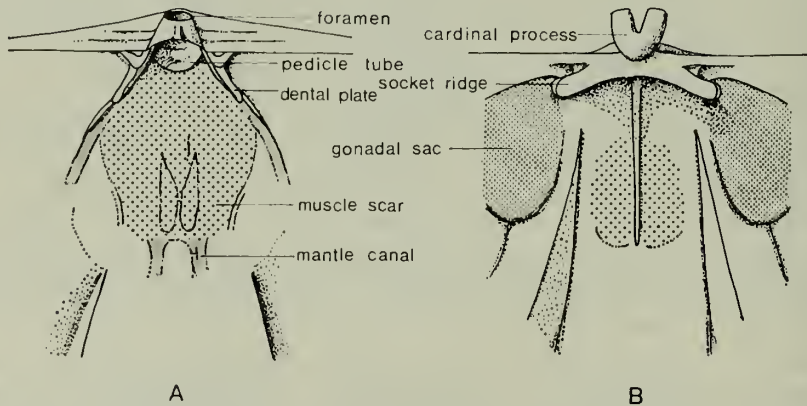


FIG. 9. Diagrammatic views of (A) the ventral and (B) the dorsal interiors of *Caeroplecia*.

TYPE MATERIAL.

		length	width (mm)
HOLOTYPE	External and internal moulds of pedicle valve (BB 35342a, b)	9.3	11.2
PARATYPES	Partly exfoliated pedicle valve with internal mould (BB 35343a, b)	12.0	—
	Internal mould of pedicle valve (BB 35344)	11.5	14.5
	Incomplete external and internal moulds of brachial valve (BB 35345a, b)	—	—
	External and internal moulds of pedicle valve (BB 35346a, b)	10.0	—
	Incomplete external and internal moulds of pedicle valve (BB 35347a, b)	—	—
	External and internal moulds of brachial valve (BB 35348a, b, c)	12.5	13.5
	External and internal moulds of brachial valve (BB 35349a, b)	12.2	15.5
	External and internal moulds of brachial valve (BB 35350a, b)	6.5	7.5
	Incomplete external and internal moulds of brachial valve (BB 35351a, b)	—	—

TYPE HORIZON AND LOCALITIES. Whittery Shales: BB 35343 and 35347 from exposures in the stream at the north end of Spring Coppice, 865 yds south-east of Hockleton Bridge near Chirbury (Grid Ref. SO 279997); BB 35350 from exposures in the lower part of the west bank of the River Camlad 60 yds north-east of Marring-ton Farm (Grid Ref. SO 272970); all other specimens from Whittery Quarry at the south end of Whittery Wood near Chirbury (Grid Ref. SO 275981).

DISCUSSION. One Welsh species, *Oxoplecia mutabilis* Williams (in Whittington & Williams 1955: 411), and possibly two American forms, the Porterfield *O. gibbosa* and the Trenton *O. pennsylvanica* (Cooper 1956: 543, 553) can be assigned to *Caeroplecia*, although the presence in the two latter species of the ridge-like concentric ornamentation so characteristic of the genus has still to be demonstrated. However, all three differ in the number of ribs on the fold, *C. mutabilis* having a greater number (6 to 12, usually 9) and the American species significantly fewer (3 or 4). *C. mutabilis*, which is probably the most closely related, also differs in being relatively wider and in having grown to lengths of 7 or 8 mm before comparatively fine costae and costellae, with a wavelength of 0.3 to 0.5 mm, appear.

TABLE 94

Statistics of length (l) and maximum width (w) of 7 brachial valves of *Caeroplecia plicata* gen. et sp. nov.

l mm (var l)	9.81 (10.558)
\bar{w} mm (var w)	12.31 (17.092)
r	0.995
a (var a)	1.2724 (0.00311)

TABLE 95

Statistics of length (l) and maximum depth (th) of 7 brachial valves of *Caeroplecia plicata* gen. et sp. nov.

l mm (var l)	9.81 (10.558)
th mm (var th)	2.89 (2.381)
r	0.865
a (var a)	0.4749 (0.01136)

TABLE 96

Statistics of length (l) and maximum width of the folds (f) in 6 brachial valves of *Caeroplecia plicata* gen. et sp. nov.

l mm (var l)	9.48 (10.686)
f mm (var f)	4.12 (2.322)
r	0.952
a (var a)	0.4661 (0.00509)

TABLE 97

Statistics of length (l) and maximum depth (th) of 10 pedicle valves of *Caeroplecia plicata* gen. et sp. nov.

l mm (var l)	11.45 (5.679)
th mm (var th)	2.02 (0.409)
r	0.636
a (var a)	0.2683 (0.00535)

OXOPLECIA Wilson 1913

1913 *Oxoplecia* Wilson : 81.

The distinction between *Oxoplecia* and *Bicuspina* is finely drawn. Ignoring the variability normally inherent to the development of a fold and sulcus, and radial and concentric ornamentation, the difference ultimately rests on the spiriferoid outline and pedicle tube of *Bicuspina* (Wright in Williams *et al.* 1965 : H358). These features are likely to have arisen by a lateral acceleration in the growth of the cardinal margins and secondary shell accretion around the internal opening of the pedicle foramen respectively, and were not always equally developed in stratigraphically earlier stocks. Thus Llandeilian *Bicuspina* of Czechoslovakia (Havlíček 1950 : 18-19) are strongly orthoid in outline, and contemporaneous *Oxoplecia* from S.W. Wales have incipient pedicle tubes (R. Addison, pers. comm.). In effect it is likely that members of the earlier-occurring and longer-ranging cosmopolitan *Oxoplecia* were ancestral to *Bicuspina*, which appears to be restricted to the Llandeilian and Caradocian rocks of Europe. It is even possible that the species described below is more closely related to *Bicuspina* than contemporaneous American *Oxoplecia* which are typically elliptical in outline, strongly uniplicate, lamellose and coarsely costellate.

Oxoplecia cf. *nantensis* MacGregor

(Pl. 20, figs. 9-13)

1961 *Oxoplecia nantensis* MacGregor : 196.

DIAGNOSIS. Subcircular, subequally biconvex *Oxoplecia* with a variably developed dorsal fold over half as wide as the brachial valve length, and fine radial ornament consisting of ribs averaging 0.3 mm in wavelength, 5 mm antero-medially of dorsal umbo.

DESCRIPTION. Small, subequally biconvex *Oxoplecia* with obtuse cardinal angles and a hinge-line about three-quarters the maximum width of the shell; pedicle valve 23% as deep as long with rounded variably defined sulcus, brachial valve 84% as long as wide and 29% as deep as long with a broadly rounded fold 57% as wide as the brachial valve is long; ventral interarea curved apsacline, pseudodeltidium with narrow median fold, dorsal interarea linear; up to 10 rounded branching ribs, usually not including a median costa and with a mean wavelength of 0.31 mm, 5 mm anterior of the umbones, occur on the folds and 10 to 12 ribs on the flanks of 5 brachial valves less than 10 mm long; concentric ornamentation of overlapping lamellae numbering about 7 between 5 and 6 mm anterior of the dorsal umbo.

Pedicle passage 5% as long as the pedicle valve, rarely with incipient traces of pedicle tube, small teeth supported by acutely divergent dental plates extending forward for 11% the length of the valve; muscle field unknown.

Cardinalia consisting of deeply bilobed cardinal process and short brachiophores, simple sockets arranged parallel to the hinge-line and extending laterally for almost one-quarter the length of the valve.

FIGURED MATERIAL.

	length	width (mm)
External and internal moulds of pedicle valve (BB 35320a, b)	8.0	8.5
Incomplete internal mould of brachial valve (BB 35321)	6.0	8.0
External and internal moulds of brachial valve (BB 35322a, b)	8.5	9.5
Incomplete internal mould of brachial valve (BB 35323)	—	—

HORIZON AND LOCALITIES. Meadowtown Beds: BB 35322 from exposures along the lane to Lower Ridge from bench mark 754, Little Weston (Grid Ref. SO 293984); the remaining specimens from temporary exposures at the side of a cart-track near Waitchley (Grid Ref. SJ 311018).

DISCUSSION. *Oxoplecia* is fairly widely distributed throughout the Lower Llandeilo rocks of Wales and Shropshire but is never common in any one locality so that data about its morphological variability are not abundant. It is, however, immediately distinguishable from penecontemporaneous *Oxoplecia* from other regions in the variable development of the fold and sulcus and especially in the fineness of the radial ornamentation. This is true even of the most closely comparable American species, the Chazyan *Oxoplecia costellata* (Cooper 1956: 540), which further differs in the late development of fold and sulcus. The few *Oxoplecia* species reported from Ordovician successions of Eurasia also differ in other attributes. *Oxoplecia sibirica*, from the Mangaseya Stage of the Siberian platform

(Nikiforova & Andreeva 1961 : 200), is additionally *Onychoplecia*-like in outline and even more finely ribbed ; while the species described by Öpik (1930 : 200) as '*Cliftonia*' *dorsata* Hisinger may prove to be a *Bicuspina* (Rõõmusoks 1970 : 121) rather than an *Oxoplecia*.

The Shelve specimens have been assigned to *Oxoplecia nantensis* MacGregor based upon material from the Upper Llandeilo of the Berwyn Hills despite the fact that measurements (MacGregor 1961 : 196) indicate the type specimens at least to be very much wider. The significance of this difference cannot be ascertained until more is known about the variability of shell outline. MacGregor's description of *O. nantensis* also suggests that the Shelve specimens have a greater number of ribs on the fold. However a photograph of the holotype (*Ibid.* pl. 20, fig. 18) shows 6 ribs on the fold in contradiction to an error in description which speaks of '3-5 ribs on the dorsal fold' (*Ibid.* : 197) ; it is possible that modal rib densities for the Shelve and Berwyn *Oxoplecia* do not greatly differ.

Order STROPHOMENIDA Öpik 1934

Suborder STROPHOMENIDINA Öpik 1934

Superfamily PLECTAMBONITACEA Jones 1928

Family LEPTESTIIDAE Öpik 1933

Subfamily LEPTESTIINAE Öpik 1933

PALAEOSTROPHOMENA Holtedahl

Palaeostrophomena sp.

(Pl. 21, figs. 7, 10, 11, 13)

DIAGNOSIS. Semicircular *Palaeostrophomena* just over half as long as wide, ornamented by unequally developed parvicostellae numbering 8 to 10 per mm, 5 mm antero-medially of the umbo, very fine fila and about 8 impermissibly concentric rugae ; ventral muscle scar bilobed divided by divergent *vascula media*.

DESCRIPTION. Semicircular *Palaeostrophomena*, with a pedicle valve 53% as long as wide, acute cardinal angles and a very gently concavo-convex profile flattening or slightly resupinate peripherally ; shell surface ornamented by very fine crowded fila, about 8 concentric rugae with a wavelength of about 0.2 mm strongly developed at acute angles to the hinge-line but becoming subdued anteriorly, and by parvicostellae numbering 8 to 10 per mm, 5 mm antero-medially of the umbo, and divided into narrow sectors by accentuated ribs, 10 or 11 of which arise early in the umbonal area ; ventral and shorter dorsal interareas apsacline and anacline respectively with a small pseudodeltidium and a supra-apical foramen, and a dorsal notothyrium filled by a median ridge representing the posterior surface of a plectambonitacean cardinal process.

Ventral interior with relatively small simple teeth, vestigial dental plates and a bilobed ventral muscle scar extending forward for about one-fifth the length of the valve and about three-fifths as long as wide ; diductor scars extending beyond the

median adductor impression divided by divergent *vascula media*. Dorsal interior unknown.

FIGURED MATERIAL.

	length	width (mm)
External and internal moulds of pedicle valve (BB 35415a, b)	8.0	14.0
External and internal moulds of pedicle valve with adherent shell (BB 35451a, b)	10.5	—
External moulds of shell (BB 35414a, b)	7.5	14.0

HORIZON AND LOCALITIES. Whittery Shales : BB 35415 from exposures half-way down path below Marrington Farm going southwards (Grid Ref. SO 272967) ; BB 35451 from the lower part of the succession in the west bank of the River Camlad, 60 yds north-east of Marrington Farm (Grid Ref. SO 272970) ; BB 35414 from Whittery Quarry at the south end of Whittery Wood near Chirbury (Grid Ref. SO 275981).

DISCUSSION. Despite the apparent absence of accessory teeth in the pedicle valve and the lack of information about the dorsal interior, a few strophomenide moulds recovered from the Whittery Shales may be safely assigned to *Palaeostrophomena* in the wider interpretation of that genus (Williams in Whittington & Williams 1955 : 415). In known characteristics, the specimens compare closely with *P. magnifica* from the Derfel Limestone of N. Wales as well as certain Scottish species from the Ardmillan Series of Scotland (Williams 1962 : 158), so that specific identification is not possible until more material is available.

Family **EOCRAMATIIDAE** nov.

DIAGNOSIS. Plectambonitaceans (?) with a complementary pseudodeltidium and chilidium, a small submesothyridid foramen, unsupported simple teeth, strong narrowly divergent chilidial plates (?) filling the notothyrium in place of a discrete platform and continuous with widely splayed cup-shaped socket ridges ; shell impunctate.

DISCUSSION. There are many features of the new genus *Eocramatia* that reflect the tendency of related major groups to show morphological convergence as they are traced back towards their common ancestry. The presence of a pseudodeltidium and chilidium indicates affinities with the Clitambonitidina, Strophomenidina and Billingsellacea. But the absence of dental plates and the structure of the cardinalia preclude assignment of the genus to the Clitambonitidina, and although the impunctate condition of the shell and the morphology of the pedicle valve suggest that *Eocramatia* was derived from the billingsellaceans, many dorsal features contradict this interpretation. These include the absence of an orthide notothyrial platform, and the nature of the divergent plates filling the notothyrium and their relationship to the socket ridges. In all, then, it seems that it can be fairly confidently assigned to the Strophomenidina.

Although only plectambonitaceans are currently known to have been contemporaneous with *Eocramatia*, representatives of the other two strophomenidine superfamilies, the Strophomenacea and Davidsoniacea, first occur in the Upper Llanvirn and basal Caradoc respectively and are stratigraphically eligible for consideration as related stocks. From a general morphological viewpoint the pseudopunctate strophomenaceans are unlikely to be related, but whether the new genus should be assigned to the plectambonitaceans or the davidsoniaceans mainly depends on the interpretation of the plates filling the notothyrium. These structures are like the chilidial plates of the leptellids and, in conjunction with the planar brachial valve and the absence of a notothyrial platform, suggest that the new genus is a plectambonitacean. On the other hand, the posterior surfaces of the plates appear to have been grooved in life and, therefore, may have functioned as supports for the dorsal diductor muscle bases which were, in contrast, attached to the notothyrial floor between the chilidial plates in plectambonitaceans. If this were so the plates are homologous with the bilobed cardinal process and, together with the impunctate shell condition and simple teeth, hint at a davidsoniacean relationship. The principal features refuting this interpretation are the attitude of the socket ridges, the absence of dental plates and the planar brachial valve; and, since simple teeth without flanking accessory processes and an impunctate shell are known to have persisted among the most primitive plectambonitaceans such as the contemporaneous plectambonitids and taffiids, it seems more appropriate to assign *Eocramatia* to the Plectambonitacea at least until better preserved material is available to decide the issues in question.

Having had so much difficulty in assigning *Eocramatia* to a superfamily it is not surprising to find that its familial connections within that taxon are at present elusive. In some respects *Eocramatia* is closest to the Taffiidae, but both the impunctate shell and the structure of the cardinalia militate against including it in that family and, in association with other features, call for the erection of a new monotypic family.

Genus *EOCRAMATIA* nov.

NAME. An early brachiopod with a mixture (Gk. κρᾶμα) of morphological features.

DIAGNOSIS. Subquadrate, slightly uniplicate plano-convex shells widest at the hinge-line, with a shallow median sulcus in the pedicle valve corresponding to a low median fold in the obscurely sulcate brachial valve; ornamentation costellate by branching and intercalation tending to thicken between intersections with concentric lamellae; ventral interarea high, curved apsacline, pseudodeltidium long, arched, foramen submesothyridid, dorsal interarea planar hypercline, chilidium small arching over the dorsal ends of high, thick, narrowly divergent chilidial plates; shell impunctate.

Ventral interior with flat semi-oval teeth embedded in thick secondary shell, dental plates absent, ventral muscle field indistinct but apparently not extending much beyond delthyrial cavity; mantle canal system obscure except for subparallel

vascula media and terminal branches but possibly associated as a pinnate pattern with low thin ridges radiating from vicinity of delthyrial cavity.

Dorsal interior with flattened, slightly indented ventral ends of chilidial plates filling notothyrial cavity and continuous with slightly convex plate-like socket ridges disposed parallel to hinge-line; notothyrial platform absent so that cardinalia overhang a shallow posteromedian depression passing anteriorly into low narrow median ridge; adductor muscle field quadripartite bounded by outwardly curving raised ridges; dorsal mantle canal pattern preserved only peripherally, possibly pinnate.

TYPE SPECIES. *Eocramatia dissimulata* sp. nov. from the Hope Shales.

Eocramatia dissimulata sp. nov.

(Pl. 21, figs. 9, 12, 14, 15; Pl. 22, figs. 1-3, 5, 6; Text-fig. 10)

DIAGNOSIS. Subquadrate, uniplicate, plano-convex *Eocramatia* with the pedicle valve 74% as long as wide and 18% as deep as long and ornamented by costellae numbering 5 per mm, 5 mm antero-medially of the ventral umbo; dorsal adductor scars limited to the posterior half of the valve.

DESCRIPTION. Subquadrate, plano-convex *Eocramatia* with 3 pedicle valves averaging 74% as long as wide (range 68% to 81%) and 18% as deep as long (range 17% to 19%) bearing a shallow median sulcus less than one-third as wide as the hinge-line and a brachial valve nearly three-fifths as long as wide bearing a vague median fold, cardinal margins acute; costellate ornamentation fine, numbering 5 per mm, 5 mm antero-medially of the umbones of 3 pedicle valves; apsacline ventral interarea 19% as long as the pedicle valve (average for 4 valves, with a range of 15% to 22%) with the pseudodeltidium extending forward for about one-seventh the length of valve, hypercline dorsal interarea shorter.

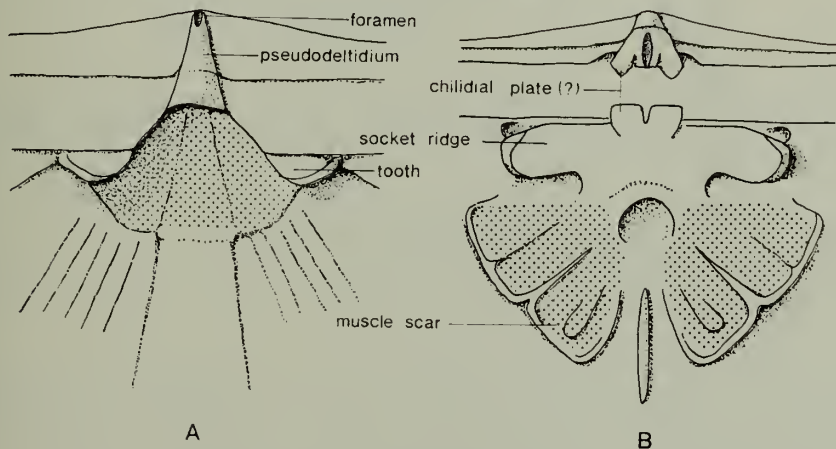


FIG. 10. Diagrammatic views of (A) the ventral interior and (B) the dorsal interior, with a posterior view of the brachial valve above, of *Eocramatia*.

Ventral interior with widely placed teeth extending laterally on either side of the delthyrium for about one-third the width of the pedicle valve, ventral subperipheral rim ill-defined. Dorsal interior with sockets elongated parallel to the hinge-line, dorsal adductor impressions limited to posterior half of the brachial valve.

TYPE MATERIAL.

		length	width (mm)
HOLOTYPE	External and internal moulds of pedicle valve (BB 35488a, b)	6.8	9.0
PARATYPES	External and internal moulds of brachial valve (BB 35489a, b)	5.2	8.0
	External and internal moulds of pedicle valve (BB 35490a, b)	5.5	7.5
	Incomplete external and internal moulds of conjoined valves (BB 35491a, b)	—	10.5
	External mould of brachial valve (BB 35492)	5.0	—

HORIZON AND LOCALITY. Hope Shales cropping out in Brithdir farmyard, 1 mile ENE of Old Church Stoke (Grid Ref. SO 301953).

DISCUSSION. No other species has yet been described that can profitably be compared with *E. dissimulata*, and as the new species is represented by only a small number of moulds few statistics can be compiled from the sample to indicate the variability of diagnostic features. These are incorporated in the description.

Family **SOWERBYELLIDAE** Öpik 1930

Subfamily **SOWERBYELLINAE** Öpik 1930

SOWERBYELLA Jones 1928

Sowerbyella antiqua Jones emended A. W.

(Pl. 22, figs. 4, 7-14; Pl. 23, figs. 1, 3, 4)

1928 *Sowerbyella antiqua* Jones : 419.

DIAGNOSIS. Semicircular *Sowerbyella* with a brachial valve 51% as long as wide, external surface very rarely ornamented by impersistent rugae finely parvicostellate with a modal count of 10 ribs per mm, 2 mm antero-medially of the dorsal umbo, infrequently segregated into sectors with a mean width of 0.57 mm; ventral muscle scar extending forward for 32% of the length of the pedicle valve; dorsal interior with a median septum usually flanked by 3 pairs of lateral septa, extending anteriorly for 56% of the length of the brachial valve and commonly united into a raised platform at the 4 mm growth stage.

DESCRIPTION. Semicircular *Sowerbyella* with acute cardinal angles, planar or very gently concave brachial valve 51% as long as wide, uniformly convex pedicle valve 27% as deep as long (range 14% to 34% for 11 specimens); ventral and dorsal interareas apsacline and anacline respectively with a supra-apical foramen and a small pseudodeltidium and a complementary chilidium; ornamentation almost

exclusively parvicostellate with counts of 9, 10, 11 and 12 ribs per mm, 2 mm antero-medially of the umbones of 6, 30, 19 and 9 brachial valves and differentiated into sectors with a mean width of 0.57 mm, 2 mm antero-medially of the umbo in 24 out of 64 valves; rugae with a wavelength of 0.15 mm rarely developed sporadically in postero-lateral areas.

Teeth small, dental plates obsolescent; ventral muscle field strongly cordate in outline, 74% as long as wide and extending forward for 32% of the length of the pedicle valve; adductor scars small, impressed as two hollows in the secondary shell of the umbo and divided by a fine median ridge; diductor scars splayed anteriorly and divided by divergent *vascula media* of a lemniscate mantle canal system.

Cardinalia consisting of a median cardinal process fused with chilidial plates and widely divergent socket plates extending anteriorly for 36% of their lateral spread and for 12% of the length of the brachial valve; notothyrial platform poorly developed; lophophore and muscle supports consisting of a median septum almost invariably flanked by 3 pairs of lateral septa and extending anteriorly for 56% of the length of the brachial valve, commonly ankylosed to form an elevated cleft platform in adult valves more than 4 mm long.

FIGURED MATERIAL.

	length	width (mm)
External mould of brachial valve (BB 35524)	4.5	9.2
Incomplete internal mould of brachial valve (BB 35525)	—	—
External mould of brachial valve (BB 35526)	5.0	10.0
Internal mould of pedicle valve (BB 35527)	6.0	8.5
External mould of pedicle valve (BB 35528)	6.0	—
Incomplete internal mould of brachial valve (BB 35529)	3.0	—
Internal mould of brachial valve (BB 35530)	3.4	7.0
Incomplete internal mould of brachial valve (BB 35531)	4.6	—
Internal mould of brachial valve (BB 35532)	5.0	10.0
Internal mould of pedicle valve (BB 35533)	5.0	9.0
Incomplete internal mould of pedicle valve (BB 35534)	2.5	—

HORIZON AND LOCALITY. Flags of the Ffairfach Group exposed on the western side of Coed Duon near Llangadog (Grid Ref. SN 709256).

Sowerbyella cf. *antiqua* Jones

(Pl. 23, figs. 2, 5-13)

DIAGNOSIS. Like *Sowerbyella antiqua* but with a ventral muscle scar extending forward for only 26% of the length of the pedicle valve.

DESCRIPTION. Semicircular, concavo-convex *Sowerbyella* with acute cardinal angles, brachial valve 50% as long as wide, pedicle valve 15% as deep as long; ventral and dorsal interareas apsacline and anacline respectively with a supra-apical foramen and a small pseudodeltidium and complementary chilidium; ornamentation exclusively parvicostellate with counts of 8, 9, 10, 11 and 12 ribs per mm,

2 mm antero-medially of the umbones of 3, 6, 10, 7 and 1 brachial valves respectively, and segregated into sectors by thickened costellae in only 2 out of 27 valves.

Teeth small, dental plates obsolescent, cordate ventral muscle field 62% as long as wide and extending forward for 26% of the length of the pedicle valve; muscle scars and mantle canal system differentiated as in *S. antiqua* s.s.

Cardinalia consisting of a median cardinal process fused with chilidial plates and widely divergent socket plates extending anteriorly for 10% of the length of the brachial valve and for an average of 28% of their lateral spread in 6 valves (range 25% to 35%); notothyrial platform poorly developed; lophophore and muscle supports consisting of a median septum flanked by 3 pairs of lateral septa, rarely more or fewer, united by secondary shell into a cleft platform in 2 out of 13 specimens over 3.5 mm long.

FIGURED MATERIAL.

	length	width (mm)
External mould of brachial valve (BB 35535)	2.5	5.5
Incomplete external mould of brachial valve (BB 35536)	2.3	—
Internal mould of pedicle valve (BB 35537a)	3.0	6.0
External mould of pedicle valve (BB 35537b)	2.8	5.8
Internal mould of brachial valve (BB 35538)	2.5	5.2
Internal mould of pedicle valve (BB 35539)	3.0	5.5
Incomplete internal mould of pedicle valve (BB 35540)	4.3	—
Internal and incomplete external moulds of brachial valve (BB 35541a, b)	4.3	8.0
Incomplete internal mould of brachial valve (BB 35542)	2.5	—

HORIZON AND LOCALITY. Flags transitional from the Meadowtown to Betton Beds exposed in a ploughed field 180 yds south-west of a wall in side of lane from Meadowtown to Castle Ring (Grid Ref. SJ 310009).

Sowerbyella multiseptata sp. nov.

(Pl. 23, figs. 14-19: Pl. 24, figs. 1, 3)

DIAGNOSIS. Semicircular *Sowerbyella* with a brachial valve 51% as long as wide, external surface very rarely ornamented by impersistent rugae, finely parvicostellate with a modal count of 10 ribs per mm, 2 mm antero-medially of the dorsal umbo; ventral muscle scar extending forward for 32% of the length of the pedicle valve; dorsal interior with a late-developing median septum usually flanked by 3 pairs of lateral septa extending anteriorly for 73% of the length of the brachial valve.

DESCRIPTION. Semicircular *Sowerbyella* with acute, rarely orthogonal, cardinal angles; brachial valve 51% as long as wide uniformly gently concave, occasionally with a narrow median fold extending from a protogulum 0.2 mm long to die out anteriorly; pedicle valve convex, rarely subcarinate, with a mean depth of 17% relative to the length of 4 valves (range 16% to 19%); ventral and dorsal interareas apsacline and anacline respectively with a supra-apical foramen and a small pseudo-deltidium and complementary chilidium; ornamentation almost exclusively finely parvicostellate with counts of 8, 9, 10 and 11 ribs per mm, 2 mm antero-medially of

the umbones of 1, 1, 7 and 4 brachial valves respectively; impersistent postero-lateral rugae very rare with a wavelength of 0.25 mm.

Teeth small, dental plates obsolescent, cordate ventral muscle field 71% as long as wide and extending forward for 32% of the length of the pedicle valve; adductor scars small, impressed in 2 hollows in the umbonal secondary shell and divided by a fine median ridge, splayed diductor scars divided by divergent *vascula media*.

Cardinalia consisting of a median cardinal process fused with chilidial plates and widely divergent socket plates extending anteriorly for an average of 30% of their lateral spread and for 10% of the length of 3 brachial valves; notothyrial platform poorly developed; lophophore and muscle supports extending anteriorly for 73% of the length of the brachial valve and consisting of a relatively short median septum developing later than a pair of strong submedial septa normally with 2 additional pairs of septa occurring lateral of the median triad, septa becoming united into a cleft platform in 2 out of 10 specimens over 2.5 mm long.

TYPE MATERIAL.

		length	width (mm)
HOLOTYPE	Internal mould of brachial valve (BB 35544)	2.8	5.3
PARATYPES	External and internal moulds of pedicle valve (BB 35545a, b)	2.6	4.8
	Internal and incomplete external moulds of pedicle valve (BB 35546a, b)	3.0	6.0
	Internal and incomplete external moulds of brachial valve (BB 35547a, b)	3.5	6.5
	External and internal moulds of pedicle valve (BB 35548a, b)	5.3	9.5
	Incomplete internal mould of brachial valve (BB 35549)	1.5	—

HORIZON AND LOCALITIES. Spy Wood Grit: BB 35547 from exposures on top of ridge 1440 yds NNE of Rorrington bench mark 599 (Grid Ref. SJ 303018); all other specimens from exposures 1100 yds NNE of Rorrington (Grid Ref. SJ 303015).

Sowerbyella cf. *sericea permixta* Williams

(Pl. 24, figs. 2, 4-7, 10)

1963 *Sowerbyella sericea* (J. de C. Sowerby) *permixta* Williams: 434.

DIAGNOSIS. Semicircular *Sowerbyella* with a brachial valve 50% as long as wide, external postero-lateral surfaces infrequently ornamented by up to 7 pairs of impersistent rugae with a wavelength of 0.3 mm and by fine parvicostellae with modal counts of 10 per mm, 2 mm antero-medially of the dorsal umbo and commonly differentiated into sectors with a mean width of 0.67 mm; ventral muscle scar extending forward for 42% of the length of the pedicle valve; dorsal interior with a median septum occurring rarely and developing late, submedial septa strong, usually flanked by a low platform with or without the differentiation of 2 pairs of lateral septa and extending anteriorly for 66% of the length of the brachial valve.

DESCRIPTION. Semicircular *Sowerbyella* with acute cardinal angles becoming roundly obtuse in late growth stages, planar to gently concave brachial valve 50% as long as wide, pedicle valve 19% as deep as long, evenly convex to subcarinate in transverse profile; ventral and dorsal interareas apsacline and anacline respectively with a supra-apical foramen and a small pseudodeltidium and complementary chilidium; radial ornamentation normally unequally parvicostellate (in 25 out of 32 brachial valves) with rib counts of 8, 9, 10, 11 and 12 per mm, 2 mm antero-medially of the umbones of 2, 7, 15, 7 and 1 brachial valves respectively, with a mean width of sectors delineated by thickened costellae of 0.67 mm; up to 7 pairs of rugae with a wavelength of 0.3 mm usually poorly and imperisistently developed in the postero-lateral areas at acute angles to the hinge-line.

Teeth small, dental plates obsolescent, cordate ventral muscle field 71% as long as wide and extending anteriorly for 42% of the length of the pedicle valve; adductor scars small, deeply inserted in a pair of hollows in the umbonal secondary shell and divided by a fine median ridge; diductor scars splayed anteriorly and divided by *vascula media* forming part of a lemniscate mantle canal system.

Cardinalia consisting of a median cardinal process fused with chilidial plates and widely divergent socket plates extending anteriorly for 33% of their lateral spread and for 13% of the length of the brachial valve; notothyrial platform poorly developed; lophophore and muscle supports normally consisting of 3 pairs of septa with a strong submedial pair extending anteriorly for 66% of the length of the brachial valve making up a low cleft platform; a short median septum was developed in only 3 out of 20 valves less than 4 mm long and in 9 out of 24 valves more than 4 mm long.

FIGURED MATERIAL.

	length	width (mm)
External and internal moulds of pedicle valve (BB 35551a, b)	7.0	13.0
External and internal moulds of brachial valve (BB 35552a, b)	3.8	7.5
External and internal moulds of brachial valve (BB 35553a, b)	4.2	8.2
External and internal moulds of brachial valve (BB 35554a, b)	4.7	9.0

HORIZON AND LOCALITY. Aldress Shales exposed in the bank of Ox Wood Dingle at the south-west corner of Ox Wood a few yards north of the Rorrington-Wotherton road (Grid Ref. SJ 290007).

Sowerbyella cf. *sericea* (J. de C. Sowerby)

(Pl. 24, figs. 11, 13, 14, 16)

1839 *Leptaena sericea* J. de C. Sowerby: 636.

1928 *Sowerbyella sericea* (J. de C. Sowerby) Jones: 414.

1963 *Sowerbyella sericea* (J. de C. Sowerby) Williams: 430.

DIAGNOSIS. Semicircular *Sowerbyella* with a brachial valve 50% as long as wide and a pedicle valve 26% as deep as long, ornamented by up to 9 pairs of imperisistent rugae with a wavelength of 0.3 mm, and unequally developed parvicostellae with a modal count of 9 per mm, 2 mm antero-medially of the dorsal umbo; ventral muscle scar extending forward for 30% of the length of the pedicle valve; dorsal interior

with strong submedian septa extending anteriorly for 69% of the length of the brachial valve.

DESCRIPTION. Semicircular *Sowerbyella* with obtusely rounded cardinal angles in adult shells, gently concave brachial valve 50% as long as wide (with a range of 47% to 52% for 5 valves), pedicle valve with a mean depth relative to length of 26% for 6 valves (range 18% to 31%) with steeply sloping sides; ventral and dorsal interareas apsacline and anacline respectively with a supra-apical foramen and a small pseudo-deltidium and complementary chilidium; radial ornamentation unequally parvicostellate with counts of 7, 8, 9, 10 and 11 ribs per mm, 2 mm antero-medially of the umbones of 1, 2, 4, 3 and 1 brachial valves respectively, with sectors delineated by thickened costellae having a mean width of 0.93 mm (for 8 estimates with a range of 0.7 to 1.2 mm); up to 9 pairs of rugae with a modal wavelength of 0.3 mm occur in the postero-lateral areas at acute angles to the hinge-line.

Teeth small, dental plates obsolescent, cordate ventral muscle field 65% as long as wide and extending anteriorly for an average of 30% of the length of 6 pedicle valves (range 24% to 38%); adductor scars deeply inserted in a pair of hollows in the umbonal secondary shell and divided by a fine median ridge; diductor scars splayed anteriorly and divided by *vascula media* forming part of a lemniscate mantle canal system.

Cardinalia consisting of a median cardinal process fused with chilidial plates and widely divergent socket plates extending anteriorly for 35% of their lateral spread and for an average of 14% of the length of 3 brachial valves; notothyrial platform poorly developed; lophophore and muscle supports normally consisting of a semi-circular platform with strong septa bounding a median cleft extending anteriorly for 69% of the length of brachial valves (range 60% to 75%).

FIGURED MATERIAL.

	length	width (mm)
Internal mould of pedicle valve (BB 35555)	8.7	14.0
External and internal moulds of brachial valve (BB 35556a, b)	6.3	12.0
Pedicle valve (BB 35557)	9.0	13.5

HORIZON AND LOCALITIES. Whittery Shales: BB 35555 from exposures in the lower part of the west bank of the River Camlad, 60 yds north-east of Marrington Farm (Grid Ref. SO 272970); BB 35556 from Whittery Quarry at the south end of Whittery Wood, near Chirbury (Grid Ref. SO 275981); BB 35557 from exposures in the stream at the north end of Spring Coppice 865 yds south-east of Hockleton Bridge (Grid Ref. SO 279997).

DISCUSSION. Species of *Sowerbyella* found in the Shelve succession belong to two distinct supra-specific groups which may eventually prove to be worth recognizing taxonomically in the manner proposed by Rõõmusoks (1959: 43), although *S. antiqua* and *S. multiseptata* are not characterized by a differentiated radial ornamentation like that found in the otherwise similar type species of his subgenus *Viruella*. Those taken from the Meadowtown Beds and Spy Wood Grit are characterized by a finely parvicostellate ornamentation only infrequently differentiated into sectors delineated by thickened ribs, and by the rare development of rugae, acutely disposed

to the hinge-line, in the postero-lateral areas. The dorsal interiors of mature valves are further distinguished by the almost invariable presence of a median septum flanked by 3 pairs of septa in various stages of coalescence. The occurrence of a median septum in these stratigraphically older *Sowerbyella* is especially significant although the timing of its appearance in relation to the submedial septa was different. In the Meadowtown sample, the median septum is at least as strongly developed as the submedial pair even in the smallest valve (1.5 mm long), which suggests that the septa were secreted more or less simultaneously presumably after the transformation of the trocholophous lophophore into a schizolophe. In the Spy Wood sample, on the other hand, the median septum is shorter than the submedial pair, and in 3 moulds less than 2 mm long it was either absent or weak indicating that it developed later than the submedial septa.

At this juncture it can be stated that the Meadowtown specimens are indistinguishable from a sample of *S. antiqua* Jones from Ffairfach flags of the Llandeilo area, not only in the early development of the median septum but in every other morphological feature except for the greater length of the ventral muscle scar in *S. antiqua* s.s. ($p < 0.001$). Although this difference is statistically significant, it seems reasonable to compare the Meadowtown material with the Welsh species.

The Spy Wood specimens differ significantly from both samples of *S. antiqua* not only in the late development of the median septum but also in the relatively faster anterior spread of the septa ($0.02 > p > 0.01$), and in the slower lateral growth of the brachial valve relative to its increase in length ($0.01 > p > 0.001$). These differences are sufficient to warrant the recognition of a new species, *S. multiseptata*, based on the Spy Wood sample.

The second distinctive group of *Sowerbyella* includes specimens recovered from the younger Aldress Shales and the Whittery and Hagley Shales. Only the Aldress sample is big enough to indicate the range of septa development. It does, however, demonstrate a further significant reduction in the development of a median septum compared with even its relatively late appearance in *S. multiseptata*. Only a pair of strong submedial septa occurred in 4 moulds less than 2.5 mm long; and a short septum had developed in only 3 out of 24 larger valves. No immature specimens of *Sowerbyella* were recovered from the Whittery and Hagley Shales, but traces of a septum were not seen in any of the 4 brachial valves examined which were between 3 and 6.6 mm long.

Comparisons of the Aldress and Whittery samples with described Caradocian *Sowerbyella* indicate that they are closely comparable with *S. sericea* (J. de C. Sowerby). The Aldress specimens in particular could be well tested statistically in relation to recently described species (Williams 1963: 430-447). It was found that they differed from *S. sericea permixta* Williams only in the relatively wider spread of the ventral muscle scar ($p < 0.001$). The Whittery and Hagley specimens, however, are more like *S. sericea* s.s. in the coarser parvicostellate ribbing, the wavelength, number and more regular occurrence of the postero-lateral rugae, and the greater relative depth of the pedicle valve. Provisionally, therefore, the stratigraphically youngest *Sowerbyella* are referred to *S. sericea* s.s. and the Aldress forms to the subspecies *permixta*.

TABLE 98

Statistics of length (l) and maximum width (w) of n brachial valves of *S. antiqua* Jones from the Ffairfach Group (A), *S. cf. antiqua* from the Meadowtown Beds (B), *S. multiseptata* sp. nov. from the Spy Wood Grit (C) and *S. cf. sericea permixta* Williams from the Address Shales (D)

	A	B	C	D
n	44	31	10	20
l mm	3.77	2.66	2.27	3.94
(var l)	(0.851)	(0.508)	(0.333)	(3.096)
\bar{w} mm	7.45	5.36	4.42	7.83
(var w)	(3.039)	(2.112)	(0.971)	(12.016)
r	0.956	0.989	0.987	0.995
$\overline{\log_e l}$	1.2988	0.9427	0.7885	1.2817
(var $\log_e l$)	(0.0579)	(0.0695)	(0.0626)	(0.1815)
$\overline{\log_e w}$	1.9816	1.6437	1.462	1.9685
(var $\log_e w$)	(0.0532)	(0.0708)	(0.0484)	(0.1789)
r_e	0.964	0.995	0.992	0.996
α	0.9582	1.0094	0.8795	0.9928
(var α)	(0.00153)	(0.00036)	(0.00161)	(0.00046)

TABLE 99

Statistics of length (l) and maximum depth (th) of n pedicle valves of *S. cf. antiqua* from the Meadowtown Beds (B) and *S. cf. sericea permixta* Williams from the Address Shales (D)
(see Table 98)

	B	D
n	10	9
l mm (var l)	3.28 (0.491)	5.11 (3.194)
th mm (var th)	0.49 (0.023)	0.97 (0.232)
r	0.883	0.795
a (var a)	0.2175 (0.0013)	0.2698 (0.00381)

TABLE 100

Statistics of length of pedicle valve (l) and length of ventral muscle scar (sc) in n examples of *S. antiqua* Jones from the Ffairfach Group (A), *S. cf. antiqua* from the Meadowtown Beds (B), *S. multiseptata* sp. nov. from the Spy Wood Grit (C) and *S. cf. sericea permixta* Williams from the Address Shales (D)

	A	B	C	D
n	37	20	15	21
l mm	4.71	3.24	3.45	5.2
(var l)	(0.831)	(0.869)	(0.941)	(3.101)
\bar{sc} mm	1.5	0.85	1.09	2.2
(var sc)	(0.157)	(0.119)	(0.146)	(1.109)
r	0.885	0.947	0.967	0.953
$\overline{\log_e l}$	1.532	1.1359	1.201	1.5954
(var $\log_e l$)	(0.0367)	(0.0794)	(0.076)	(0.1083)
$\overline{\log_e sc}$	0.3697	-0.239	0.0316	0.6878
(var $\log_e sc$)	(0.0675)	(0.153)	(0.1153)	(0.2055)
r_e	0.898	0.954	0.969	0.9611
α	1.3567	1.3878	1.2317	1.3776
(var α)	(0.01014)	(0.00959)	(0.00712)	(0.00761)

TABLE IOI

Statistics of length (l) and width (w) of ventral muscle scar in n pedicle valves of *S. antiqua* Jones from the Ffairfach Group (A), *S. cf. antiqua* from the Meadowtown Beds (B), *S. multiseptata* sp. nov. from the Spy Wood Grit (C), and *S. cf. sericea permixta* Williams from the Address Shales (D)

	A	B	C	D
n	33	15	7	18
l mm	1.51	0.83	1.16	2.32
(var l)	(0.154)	(0.081)	(0.209)	(1.054)
\bar{w} mm	2.04	1.33	1.63	3.28
(var w)	(0.216)	(0.167)	(0.339)	(1.581)
\bar{r}	0.869	0.974	0.975	0.961
$\log_e \bar{l}$	0.3767	-0.2373	0.0734	0.7534
(var $\log_e \bar{l}$)	(0.0656)	(0.1101)	(0.1451)	(0.1783)
$\log_e \bar{w}$	0.6873	0.2429	0.4276	1.1204
(var $\log_e \bar{w}$)	(0.0506)	(0.0895)	(0.1202)	(0.1368)
r_e	0.874	0.975	0.977	0.965
α	0.8782	0.9018	0.91	0.8758
(var α)	(0.00585)	(0.00306)	(0.00756)	(0.00325)

TABLE IO2

Statistics of length (l) and maximum anterior extension of socket ridges (lc) in n brachial valves of *S. antiqua* Jones from the Ffairfach Group (A), *S. cf. antiqua* from the Meadowtown Beds (B) and *S. cf. sericea permixta* Williams from the Address Shales (D)

	A	B	D
n	40	20	32
l mm	4.26	2.97	4.13
(var l)	(0.716)	(0.684)	(1.768)
\bar{lc} mm	0.5	0.28	0.52
(var lc)	(0.016)	(0.012)	(0.041)
\bar{r}	0.918	0.945	0.918
$\log_e \bar{l}$	1.4305	1.0531	1.3685
(var $\log_e \bar{l}$)	(0.0386)	(0.0742)	(0.0987)
$\log_e \bar{lc}$	-0.7301	-1.3233	-0.7273
(var $\log_e \bar{lc}$)	(0.0639)	(0.1363)	(0.1419)
r_e	0.924	0.954	0.924
α	1.2867	1.3554	1.1991
(var α)	(0.00633)	(0.00923)	(0.00704)

TABLE IO3

Statistics of maximum anterior (l) and maximum lateral (w) extensions of socket ridges in n brachial valves of *S. antiqua* Jones from the Ffairfach Group (A) and *S. cf. sericea permixta* Williams from the Address Shales (D)

	A	D
n	28	21
l mm (var l)	0.52 (0.056)	0.54 (0.036)
\bar{w} mm (var w)	1.47 (0.107)	1.59 (0.209)
\bar{r}	0.678	0.826
$\log_e \bar{l}$ (var $\log_e \bar{l}$)	-0.7365 (0.1844)	-0.6789 (0.1186)
$\log_e \bar{w}$ (var $\log_e \bar{w}$)	0.3595 (0.0483)	0.4274 (0.0789)
r_e	0.696	0.835
α (var α)	0.5117 (0.00519)	0.8159 (0.0106)

TABLE 104

Statistics of length (l) and maximum anterior extension of septa (ls) in n brachial valves of *S. antiqua* Jones from the Ffairfach Group (A), *S. cf. antiqua* from the Meadowntown Beds (B), *S. multiseptata* sp. nov. from the Spy Wood Grit (C) and *S. cf. sericea permixta* Williams from the Aldress Shales (D)

	A	B	C	D
n	54	35	13	43
l mm	4.2	2.98	2.73	4.07
(var l)	(0.599)	(0.591)	(0.424)	(1.876)
ls mm	2.34	1.81	1.98	2.68
(var ls)	(0.195)	(0.2)	(0.305)	(0.861)
r	0.926	0.954	0.915	0.969
a	0.5697	0.5817	0.8478	0.6774
(var a)	(0.00088)	(0.00092)	(0.01065)	(0.00068)

Subfamily **AEGIROMENINAE** Havlíček 1961

SERICOIDEA Lindström 1953

Sericoidea cf. *abdita* Williams

(Pl. 24, figs. 8, 9, 12, 15, 17, 18; Pl. 28, fig. 16)

1955 *Sericoidea abdita* Williams: 418.

DIAGNOSIS. Semicircular *Sericoidea* with a brachial valve 54% as long as wide and ornamented by unequally developed parvicostellae commonly numbering 11 or 12 per mm, 2 mm antero-medially of the dorsal umbo; median and submedial septa in adult brachial valves extending forwards for about two-thirds the valve length bounded anteriorly by an arc of septules.

DESCRIPTION. Semicircular, concavo-convex *Sericoidea* with a concave brachial valve averaging 54% as long as wide in 6 valves (range 50% to 64%) and an evenly convex pedicle valve with a mean depth for 3 valves of 11.3% (range 8.7% to 13.6%); ventral and dorsal interareas apsacline and anacline, supra-apical foramen open in adult pedicle valves; protegulum about 0.2 mm long; radial ornamentation unequally parvicostellate with rib frequencies of 11, 12 and 13 per mm, 2 mm antero-medially of the umbones of 3, 3 and 1 brachial valves, divided into sectors about 0.5 mm wide by accentuated costae and costellae; impersistent rugae with a wavelength of about 0.1 mm occur postero-laterally at acute angles to the hinge-line.

Ventral interior with unsupported oblique teeth; subquadrate ventral muscle scar about as wide as long and extending forward for 28% of the length of the pedicle valve, bounded by low subparallel ridges trailing anteriorly from the tooth bases and divided postero-medially by a thin median ridge.

Dorsal interior with widely splayed socket ridges extending anteriorly for about 8% of the length of the valve; lophophore supports of adult valves consisting of a median septum flanked by a pair of submedial septa extending forward for 62.8% of the length of 6 brachial valves (range 54% to 80%) and a peripheral arc of about 8 septules.

FIGURED MATERIAL.

	length	width (mm)
External and incomplete internal moulds of brachial valve (BB 35484a, b)	2.5	3.9
Internal mould of brachial valve (BB 35485)	2.2	4.1
External and internal moulds of brachial valve (BB 35486a, b)	1.3	2.6
External and internal moulds of pedicle valve (BB 35487a, b)	2.2	—

HORIZON AND LOCALITY. Hagley Shales: interbedded tuff exposed in north end of coppice 300 yds north-east of Calcot, Church Stoke (Grid Ref. SO 275961).

DISCUSSION. The only *Sericoidea* found in the Shelve area occur in fine-grained tuffs associated with the Hagley Shales and Volcanics. Specimens are not common but moulds of the brachial valves recovered show that the sample is closely related to *S. abdita* Williams from the Derfel Limestone of the Arenig area (Williams in Williams & Whittington 1955: 418; Williams 1962: 188). In the smallest brachial valves up to 1.6 mm long the median septum and a peripheral arc of sharp tubercles were strongly developed but the submedial septa only incipiently so. Further growth included an acceleration in the secretion of the submedial septa to amalgamate with the median septum and an accentuation of the arc of tubercles into discrete septules. Both *S. abdita* from Wales and *S. aff. abdita* from the Balclatchie Group of Girvan were characterized by the development of a similarly differentiated and proportioned lophophore platform. Indeed the only differences between the Shelve *Sericoidea* and those from Wales and Scotland is that the ribbing of the former is slightly coarser and the brachial valve relatively longer, although on available evidence these differences are not significant.

Superfamily **STROPHOMENACEA** King 1846

Family **STROPHOMENIDAE** King 1846

Subfamily **FURCITELLINAE** Williams 1965

FURCITELLA Cooper 1956

Furcitella sp.

(Pl. 25, figs. 4, 5)

The external and internal moulds of a strophomenid brachial valve (BB 35422a, b), from the Whittery Shales exposed in Whittery Quarry at the south end of Whittery Wood near Chirbury (Grid Ref. SO 275981), have been provisionally identified as *Furcitella*. The valve which was 7.5 mm long was almost semicircular in outline with slightly obtuse cardinal angles. The valve was also resupinate, being flat up to the 2.5 mm growth stage but thereafter becoming convex to attain an overall depth of 10% of the length. The external surface was ornamented by fine, equally developed costellae numbering 8 per mm, 5 mm antero-medially of the umbo and crossed by fine fila with frequencies of up to 18 per mm. The surface also undulated as impersistent rugae with wavelengths of about 0.5 mm. The internal features are poorly preserved but the cardinalia and muscle boundaries can be identified as

including a bilobed cardinal process, widely divergent socket ridges, a notothyrial platform extending forward for less than one-third the length of the valve into a median ridge possibly bifurcating anteriorly, and a pair of divergent transmuscle septa.

In respect of its ornamentation, profile and internal features, the brachial valve is not only identifiable as *Furcitella* but also closely comparable with the type species *F. plicata* from the Oranda Formation of Virginia (Cooper 1956 : 877), although on the basis of impressions of only one valve specific identification would not be reliable.

MURINELLA Cooper 1956

Murinella sp.

(Pl. 25, figs. 2, 3)

The incomplete external and internal moulds of a pedicle valve (BB 35421a, b), collected from the Meadowtown Beds exposed along the lane to Lower Ridge from bench mark 754, Little Weston (Grid Ref. SO 293984), are best identified as the strophomenid *Murinella*. The valve was 6.5 mm long and, when complete, must have been semi-elliptical in outline with slightly acute cardinal angles, and evenly convex with only a faintly developed median carina, giving a maximum depth relative to length of about 10%. The ornamentation was finely costellate with 6 ribs per mm at 5 mm antero-medially of the umbo, crossed by fine fila and coarser sporadically occurring growth lines. A pedicle foramen truncated the beak and the relatively small teeth protruding dorsally of the apsacline interarea were supported by short, widely divergent dental plates. The muscle scar was transversely elliptical, extending forward for about one-third the length of the valve and about two-thirds as long as wide. The various components of the muscle field are not identifiable but there is a conspicuous median septum culminating in a point at the anterior boundary of the scar and trailing forward beyond the boundary for a short distance as a low ridge.

The nature of the radial ornamentation, the even convexity of the valve and especially the presence of a median septum in the muscle scar differentiate the valve as belonging to *Murinella*. Indeed except for the greater extension of the median septum beyond the anterior boundary of the muscle scar the valve compares closely with the type species for the genus, *M. partita* from the Bromide Formation of Oklahoma (Cooper 1956 : 848) : however, more material may demonstrate that the Shropshire form is quite distinct.

Subfamily **RAFINESQUININAE** Schuchert 1893

RAFINESQUINA Hall & Clarke 1892

Rafinesquina delicata sp. nov.

(Pl. 25, figs. 6-13)

DIAGNOSIS. Plano- to gently concavo-convex *Rafinesquina* with a pedicle valve 8% as deep as long and a brachial valve 79% as long as wide, radial ornamentation

unequally parvicostellate with 7 ribs per mm, 10 mm antero-medially of the dorsal umbo; ventral muscle scar feebly impressed subcircular, as long as wide and extending anteriorly for 28% of the length of the pedicle valve; cardinalia delicately developed, notothyrial platform vestigial except in late growth stages.

DESCRIPTION. Plano- to gently concavo-convex, transversely semi-elliptical *Rafinesquina* with cardinal angles normally orthogonal but also obtuse or acute especially the latter in young shells; pedicle valve evenly convex, 8% as deep as long (range 7% to 10% for 6 valves), brachial valve flat or slightly concave, rarely with a dorsally deflected margin, 79% as long as wide with a strongly convex trilobed protogulum 0.7 mm long; ventral interarea apsacline with a large supra-apical foramen and a small pseudodeltidium, dorsal interarea narrow anacline with a large convex, medially indented chilidium; radial ornamentation unequally parvicostellate, rarely with a thickened median rib, with counts of 6, 7, 8 and 9 ribs per mm, 10 mm antero-medially of the umbones of 10, 13, 3 and 1 brachial valves respectively.

Ellipsoidal teeth obliquely disposed parallel with the widely divergent dental plates reaching anteriorly for 9% of the length of the pedicle valve; ventral muscle field subcircular, 99% as wide as long and extending forward for 28% of the length of the valve, usually faintly developed and consisting of a broad adductor scar impressed on either side of a median ridge and a pair of flanking semicircular diductor scars; internal surface rarely coarsely tuberculate, mantle canal system unknown.

Cardinal process lobes delicate, plate-like, slightly splayed and ankylosed to widely divergent thin socket ridges extending anteriorly for 9% of the length of the brachial valve and 31% of their lateral extension; concave surfaces of narrow sockets normally tuberculate in adult valves; notothyrial platform poorly developed except as a low anchor-shaped feature in late adult growth stages so that the cardinalia usually bound slight postero-medial hollows in younger valves; median ridge and transmuscle septa rarely developed, extending forward for about two-fifths the length of the valve; only the posterior pair of reniform adductor scars known, extending anteriorly for 30% of the length of the valve; subperipheral rim, up to 2 mm wide, rarely developed.

TYPE MATERIAL.

		length	width (mm)
HOLOTYPE	External and internal moulds of brachial valve (BB 35558a, b)	12.5	17.0
PARATYPES	External and internal moulds of pedicle valve (BB 35559a, b)	13.0	14.5
	External and internal moulds of pedicle valve (BB 35560a, b)	14.0	—
	External and internal moulds of pedicle valve (BB 35561a, b)	11.5	12.0
	Incomplete internal mould of brachial valve (BB 35562)	—	—

	length	width (mm)
External and internal moulds of brachial valve (BB 35563a, b)	10.0	11.5
External and internal moulds of brachial valve (BB 35564a, b)	7.5	9.0

HORIZON AND LOCALITIES. Meadowtown Beds: BB 35558 and BB 35564 from exposures 100 yds south-east of Minicop Farm (Grid Ref. SJ 315018); all other specimens from Quinton's Quarry in a field 200 yds north-east of Meadowtown Chapel (Grid Ref. SJ 312013).

DISCUSSION. The *Rafinesquina* found sporadically in the Betton Beds and occurring abundantly in the Meadowtown Beds (Tables 105-110) is especially characterized by the delicacy of its cardinalia, the weakness of its notothyrial platform and the smallness of its subcircular ventral muscle scar. Indeed if it were not for the presence of strongly developed dental plates, the species would have been more appropriately classified as *Platymena* (Cooper 1956: 879). The nature of these features also serves to distinguish the new species from its closest relative, the Upper Llandeilo *R. simplex* (MacGregor 1961: 205) which, in particular, has a better defined notothyrial platform and significantly larger ventral muscle scar. In the absence of statistical data from MacGregor's account of *R. simplex*, no other difference may be categorically identified at present, although the brachial valve of the Welsh species may prove to be relatively wider than that of *R. delicata*.

Rafinesquina sp.

(Pl. 25, fig. 1; Pl. 26, fig. 1)

The only specimens from the Whittery Shales referable to *Rafinesquina* are incomplete complementary external and internal moulds of a brachial valve (BB 35496a, b) recovered from Whittery Quarry at the south end of Whittery Wood, near Chirbury (Grid Ref. SO 275981). The valve was gently concave with a prominent protogulum about 0.5 mm long and an unequally parvicostellate radial ornamentation with a density of 10 ribs per mm antero-medially of the umbo. Impersistent rugae up to 2 mm in wavelength were developed in arcs concentric to the umbo and immediately distinguish the specimen from the Meadowtown *Rafinesquina*. Internally the cardinal process lobes were ridge-like and slightly divergent and capped postero-medially by a strong chilidium. The socket ridges were narrow and low and the anchor-shaped notothyrial platform weakly developed with only one pair of transmuscle septa evident.

A number of strophomenids have been recorded from the Caradocian rocks of England and Wales as *Rafinesquina expansa* (Sowerby) but the species requires revision because, as currently understood (Davidson 1871: 312), it includes specimens that are not even congeneric; and until more material is available no comparisons are trustworthy.

TABLE 105

Statistics of length (l) and maximum width (w) of 37 brachial valves of *Rafinesquina delicata* sp. nov.

l mm (var l)	6.92 (17.715)
\bar{w} mm (var w)	8.75 (25.535)
r	0.994
$\overline{\log_e l}$ (var $\log_e l$)	1.7778 (0.3143)
$\log_{e w}$ (var $\log_{e w}$)	2.0247 (0.2880)
r_e	0.996
α (var α)	0.9572 (0.00022)

TABLE 106

Statistics of length (l) and maximum anterior extension of socket ridges (lc) in 18 brachial valves of *Rafinesquina delicata* sp. nov.

l mm (var l)	10.64 (16.557)
\bar{lc} mm (var lc)	0.98 (0.15)
r	0.937
a (var a)	0.095 (0.00006)

TABLE 107

Statistics of maximum anterior (l) and maximum lateral (w) extensions of socket ridges in 10 brachial valves of *Rafinesquina delicata* sp. nov.

l mm (var l)	0.86 (0.198)
\bar{w} mm (var w)	2.61 (0.934)
r	0.928
$\overline{\log_e l}$ (var $\log_e l$)	-0.2694 (0.2374)
$\log_{e w}$ (var $\log_{e w}$)	0.8951 (0.1283)
r_e	0.937
α (var α)	0.7352 (0.00819)

TABLE 108

Statistics of length (l) and length of dental plates (dl) in 45 pedicle valves of *Rafinesquina delicata* sp. nov.

l mm (var l)	11.16 (16.566)
\bar{dl} mm (var dl)	1.03 (0.124)
r	0.864
a (var a)	0.0867 (0.00004)

TABLE 109

Statistics of length (l) and length of ventral muscle scar (sc) in 25 pedicle valves of *Rafinesquina delicata* sp. nov.

l mm (var l)	12.4 (10.79)
\bar{sc} mm (var sc)	3.51 (1.804)
r	0.916
$\overline{\log_e l}$ (var $\log_e l$)	2.4839 (0.0677)
$\log_{e sc}$ (var $\log_{e sc}$)	1.1867 (0.1366)
r_e	0.923
α (var α)	1.4209 (0.01296)

TABLE 110

Statistics of length (l) and width (w) of the ventral muscle scar in 23 pedicle valves of *Rafinesquina delicata* sp. nov.

l mm (var l)	3.6 (1.351)
\bar{w} mm (var w)	3.56 (1.107)
r	0.96
a (var a)	0.9052 (0.00302)

***KJAERINA (HEDSTROEMINA)* Bancroft 1929**

***Kjaerina (Hedstroemina)* sp.**

(Pl. 26, fig. 2)

The internal mould of a pedicle valve (BB 35452) from the Spy Wood Grit cropping out 1100 yds NNE of Rorrington (Grid Ref. SJ 303015) will probably be shown to represent a new species of the *Kjaerina* species group known as *Hedstroemina* (Bancroft 1929: 56). The convex valve was about 20 mm long and an estimated 30 mm wide with roundly obtuse cardinal angles affected by a strong but sharply obtuse geniculation to define a relatively flat disc about 10.5 mm long and a trail 15 mm long. Fragments of the external mould at the antero-medial margin indicated that the radial ornamentation was coarsely unequally parvicostellate with about 4 ribs per mm. The ventral interarea was strongly apsacline, the foramen large and supra-apical with a small or resorbed pseudodeltidium. The well-developed teeth were supported by divergent dental plates subtending an angle of about 100° and extending forward for about 15% of the length of the disc. Low convergent ridges extended from the anterior ends of the dental plates to enclose a subcircular muscle field about 70% as long as the disc with a broad median adductor scar extending anteriorly as far as the subflabellate diductor impressions.

The specimen is quite distinct from other known *Hedstroemina* in the strong geniculation of the valve and the large size of the scar in relation to the disc. The Actonian *H. robusta* (Bancroft 1929: 59) and *H. holtedahli* (Spjeldnaes 1957: 131) from the 4 α - β horizons of Norway compare most closely, but neither is so sharply deflected nor characterized by so small a disc.

Subfamily **GLYPTOMENINAE** Williams 1965

***BYSTROMENA* gen. nov.**

NAME. A strophomenacean with the posterior of the adult pedicle valve blocked by a plug (Gk. βύστρον).

DIAGNOSIS. Concavo-convex, semi-elliptical strophomenids with large protegula, ornamented by parvicostellae which may be unequally developed in early growth stages; ventral and dorsal interareas apsacline and anacline respectively, pseudodeltidium bounding a large supra-apical foramen truncating the ventral beak, arched chilidium relatively large.

Ventral interior with obliquely placed teeth supported by short widely divergent dental plates; umbonal region of mature valves occupied by a short cylindroid plug of secondary shell with a median groove on the dorsal surface; ventral muscle scar obscure, floors of mature valve with many radiating partitions suggesting a lemniscate mantle canal system.

Dorsal interior with delicate cardinalia consisting of a small bilobed cardinal process with a vestigial median ridge present between the lobes in young specimens, each lobe continuous with widely divergent socket ridges; notothyrial platform absent in young specimens so that the postero-medial part of the valve floor enclosed by the cardinalia forms a hollow which is filled in mature valves by a low median ridge bifurcating anteriorly; muscle scars obscure with two pairs of transmuscle septa identifiable in young specimens but masked in adult valves by strongly developed radiating partitions associated with a lemniscate mantle canal system.

TYPE SPECIES. *Bystromena perplexa* sp. nov. from the Spy Wood Grit of the Shelve area, Shropshire.

DISCUSSION. The shape of the shell, the disposition of the teeth and their supports and the delicacy of the cardinalia indicate that the new genus is closely related to the Glyptomeninae (Williams in Williams *et al.* 1965 : H388). Yet other features immediately distinguish *Bystromena* from known members of that subfamily. They include the tendency for the ribbing to be costellate rather than unequally parvicostellate, although the general pattern is like that of *Platymena* (Cooper 1956 : 879), and the development of radiating partitions in the interior of adult shells. However, the most important distinction is undoubtedly the cylindroid mass of secondary shell plugging the postero-medial part of the beak interior in adult shells. The plug is in striking contrast to the well-developed foramen in young valves. There are, moreover, indications that the anterior surface of the plug forms a hollow which suggests that the structure was an internal pedicle tube, like those found in some triplesiaceans (Wright 1963 : 744), but filled in with secondary shell following atrophy of the pedicle.

Bystromena perplexa sp. nov.

(Pl. 25, fig. 14; Pl. 26, figs. 3-14; Pl. 27, figs. 1, 2; Text-fig. 11)

DIAGNOSIS. Transversely semi-elliptical *Bystromena* with a brachial valve about three-quarters as long as wide and gently concave umbonally flattening peripherally in maturity, and an evenly convex pedicle valve about one-tenth as deep as long; radial ornamentation finely costellate in adult shells with a modal count of 7 per mm, 5 mm antero-medially of the umbo.

DESCRIPTION. Transversely semi-elliptical *Bystromena* with slightly acute to obtuse cardinal angles, brachial valve about three-quarters as long as wide, slightly concave in the umbonal region but flattening peripherally in adult growth stages, pedicle valve evenly convex and about one-tenth as deep as long, protegulum large, trilobed up to 1 mm long; radial ornamentation commonly unequally parvicostellate in early growth stages but becoming costellate in adult shells with counts of 5, 6, 7

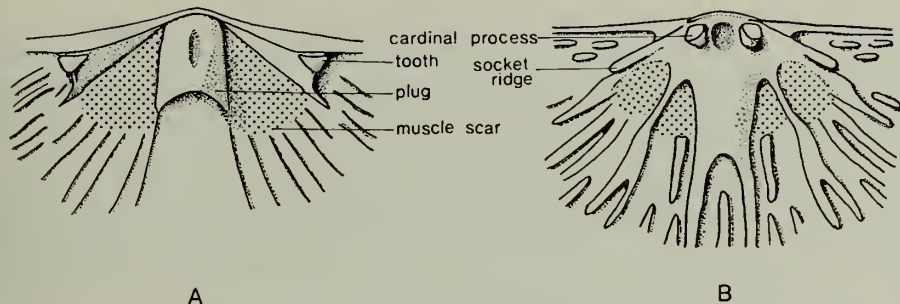


FIG. 11. Diagrammatic views of (A) the ventral and (B) the dorsal interiors of *Bystromena*.

and 8 ribs per mm, 5 mm antero-medially of the umbones, of 3, 1, 4 and 1 valves respectively ; ventral and dorsal interareas apsacline and anacline respectively with a functional foramen at least in young pedicle valves, and well-developed pseudo-deltidium and chilidium.

Teeth obliquely disposed ridges supported by widely divergent dental plates extending anteriorly for less than one-tenth of the pedicle valve ; ventral muscle field obscure, cylindroid infilled pedicle tube, with a shallow median furrow on the dorsal surface, extending anteriorly for about 1 mm ; floor of mature valve ornamented by many radiating thin partitions.

Cardinal process small with vestigial median ridge present between the lobes in immature valves, lobes continuous with widely divergent socket ridges subtending an angle of about 135° ; notothyrial platform absent except in mature valves when it extended forward for a short distance as a median ridge bifurcating anteriorly ; transmuscle septa present but usually obscured by radiating thin partitions delineating a pinnate mantle canal system ; dorsal muscle impressions obscure.

TYPE MATERIAL.

		length	width (mm)
HOLOTYPE	Internal mould of pedicle valve (BB 35363)	8.0	11.5
PARATYPES	External and internal moulds of incomplete pedicle valve (BB 35364a, b)	-	-
	External and internal moulds of pedicle valve (BB 35365a, b)	6.0	8.0
	External and internal moulds of pedicle valve (BB 35366a, b)	4.5	-
	External and internal moulds of brachial valve (BB 35367a, b)	5.0	6.5
	External and internal moulds of brachial valve (BB 35368a, b)	4.0	-
	Incomplete internal mould of pedicle valve (BB 35369)	-	-
	Incomplete internal mould of brachial valve (BB 35370)	-	-

TYPE HORIZON AND LOCALITIES. Spy Wood Grit: BB 35363, 35365 from exposures on top of ridge 1440 yds NNE of Rorrington bench mark 599 (Grid Ref. SJ 303018); BB 35364, 35370 from outcrops 1100 yds NNE of Rorrington (Grid Ref. SJ 303015); BB 35368, 35369 from the north bank of Spy Wood Brook, 170 yds north-east of Spy Wood Cottage (Grid Ref. SO 282958); BB 35366, 35367 from exposures 700 yds NNW of Middleton Church (Grid Ref. SO 296998).

DISCUSSION. As far as is known, no previously described species can be assigned to *Bystromena*; and even *B. perplexa* is represented by only a few moulds, mostly imperfectly preserved, from the Spy Wood Grit so that much remains to be discovered about the variability of the new species itself.

Family **LEPTAENIDAE** Hall & Clarke 1894

LEPTAENA Dalman 1828

Leptaena cf. *ventricosa* Williams

(Pl. 27, figs. 5, 8, 9)

DIAGNOSIS. *Leptaena* with a semicircular disc about 10 mm long, ornamented by relatively coarse costellae numbering 4 per mm, 5 mm antero-medially of the umbo and about 9 low concentric rugae on the disc with a wavelength of 1 mm, sub-circular ventral muscle scar less than two-thirds as long as the disc.

DESCRIPTION. Concavo-convex, sharply geniculate and subquadrate *Leptaena* with a semicircular disc about 10 mm long, almost twice as wide and about one-eighth as deep in the vicinity of the ventral umbo, well defined by a confining fold with a wavelength of 2 mm, trail sharply deflected at about 90° to give an overall depth of about half the length of the pedicle valve; ventral and dorsal interareas apsacline and anacline respectively with a small pseudodeltidium truncated by a large open supra-apical foramen and a well-developed chilidium; radial ornamentation finely but evenly costellate with 4 per mm, 5 mm antero-medially of the umbo; 9 more or less continuous concentric rugae with a wavelength of about 1 mm also ornament the disc.

Teeth obliquely disposed and supported by short widely divergent dental plates; ventral muscle field not well preserved but apparently rhomboidal in outline and about three-fifths as long as the disc.

Cardinalia poorly preserved but a strong bilobed cardinal process, widely splayed socket ridges and an anchor-shaped notothyrial platform were identifiable, as were the transmuscle septa especially the longer, curved submedial pair which extend anteriorly for about four-fifths of the length.

FIGURED MATERIAL.

	length	width (mm)
External and internal moulds of brachial valve (BB 35453a, b)	—	—
Internal mould of pedicle valve (BB 35454)	—	—

HORIZON AND LOCALITIES. Whittery Shales: BB 35454 from exposures in the stream at the north end of Spring Coppice, 865 yds south-east of Hockleton Bridge

(Grid Ref. SO 279997) ; BB 35453 from exposures half-way down the path going southwards below Marrington Farm (Grid Ref. SO 272967).

DISCUSSION. The few impressions of *Leptaena* found in the Whittery and Hagley Shales compare very closely with those of *L. ventricosa* Williams (1963 : 462) from the Gelli-grin Group of the Bala district. The disc of *L. ventricosa* s.s., which is about three-fifths as long as wide, as well as the ventral muscle scar, may prove to be consistently longer ; but provisionally the Shropshire material is reasonably identified as conspecific with the Welsh.

KIAEROMENA Spjeldnaes 1957

Kiaeromena* cf. *kjerulfi (Holtedahl)

(Pl. 27, figs. 6, 10, 11)

1916 *Leptaena kjerulfi* Holtedahl : 72.

1957 *Kiaeromena kjerulfi* (Holtedahl) Spjeldnaes : 183.

1963 *Kiaeromena* cf. *kjerulfi* (Holtedahl) Williams : 464.

DIAGNOSIS. Obtusely geniculate *Kiaeromena* with a disc about 12 mm long, ornamented by up to 9 coarse concentric rugae and unequally developed parvicostellae numbering about 6 per mm, 10 mm antero-medially of the ventral umbo ; subcircular ventral muscle field about 6 mm long.

DESCRIPTION. Subquadrate *Kiaeromena* with a rounded obtuse angle of geniculation to define a plano-convex disc about 12 mm long and almost twice as wide ornamented by up to 9 coarse concentric asymmetric rugae with wavelengths of 1.5 mm and steeper posterior slopes ; radial ornamentation unequally parvicostellate especially on the trail with a count of 6 per mm, 10 mm antero-medially of the ventral umbo ; ventral and shorter dorsal interareas apsacline and anacline respectively with the pseudodeltidium and beak pierced by a large supra-apical foramen, and an arched childium.

Ventral interior with trigonal teeth supported by divergent dental plates acting as the posterior boundaries of a poorly preserved subcircular muscle scar extending forward for about 6 mm.

Dorsal interior with a cardinal process consisting of a small median ridge flanked by two acutely divergent lobes and poorly defined socket ridges supported by a massive, anchor-shaped notothyrial platform.

FIGURED MATERIAL.

	length	width (mm)
Incomplete external and internal moulds of pedicle valve (BB 35406a, b)	25	—
Incomplete external and internal moulds of brachial valve (BB 37132a, b)	—	—

HORIZONS AND LOCALITIES. BB 35406 from Whittery Shales exposed in the lower part of the west bank of the River Camlad, 60 yds north-east of Marrington Farm (Grid Ref. SO 272970) ; BB 37132 from Hagley Volcanics exposed in a roadside quarry 150 yds north of Church Stoke Hall (Grid Ref. SO 274942).

DISCUSSION. Only a few incomplete moulds of a finely ribbed, obtusely geniculate leptaenid have been recovered from the Hagley and Whittery Shales. There is no doubt, however, about the generic identity of the specimens which compare sufficiently closely with *Kiaeromena* cf. *kjerulfi*, occurring rarely in the Allt Ddu Group of the Bala district (Williams 1963 : 464), to be regarded as conspecific.

Order PENTAMERIDA Schuchert & Cooper 1931
 Suborder SYNTROPHIIDINA Ulrich & Cooper 1936
 Superfamily **PORAMBONITACEA** Davidson 1853
 Family **SYNTROPHIIDAE** Schuchert 1896
 Subfamily **XENELASMATINAE** Ulrich & Cooper 1936
EUORTHSINA Havlíček 1950

The genus *Euorthisina* Havlíček (1950 : 16) was not included by Biernat in her review of the Porambonitacea (in Williams *et al.* 1965 : H523-536). But, as demonstrated by Havlíček, the genus is undoubtedly a porambonitacean although unique in its shape within the superfamily. This difference is related to the strong development of wide interareas in both valves and the absence of a dorsal fold and ventral sulcus. Such features are normally quite variable in other articulates but they are so exceptional among the porambonitaceans as to prompt Biernat (1965 : H524) to report that within the superfamily the interareas are 'commonly reduced and scarcely visible' and that the 'anterior commissure is invariably uniplicate'. Neither diagnosis is true of *Euorthisina* which is, accordingly, immediately distinguishable from all other porambonitaceans. Through the kindness of Dr Havlíček, it is possible to figure here internal moulds of *Euorthisina moesta* (Barrande) from the Llanvirnian Šárka formation of Rokycany (Pl. 28, figs. 4, 6, 7) which show the main features of the genus (BB 37160-37162).

Havlíček (1950 : 16) compared his genus with *Xenelasma* (Ulrich & Cooper 1936 : 631) which is also characterized by discrete dental plates and a septalium. It is, however, possible that the internal similarity is an expression of convergence, but until more is known about the ancestry of *Euorthisina* it seems more practicable to follow Havlíček's lead and provisionally retain the genus within the Xenelasmatinae.

Euorthisina* cf. *moesta minor Havlíček

(Pl. 28, figs. 1-3, 5, 8)

1950 *Euorthisina moesta minor* Havlíček : 87.

DIAGNOSIS. Subequally and evenly biconvex, transversely suboval *Euorthisina* ornamented by fine lamellae and costellae numbering 3 per mm, 5 mm antero-medially of the ventral umbo ; parallel dental plates and septalium extending forward for about one-fifth the length of their respective valves.

DESCRIPTION. Transversely suboval *Euorthisina* with a gently convex brachial valve about 60% as long as wide and a pedicle valve about 15% as deep as long with

an evenly and gently convex transverse profile; ornamented by fine closely spaced lamellae and rounded ribs composed of 9 primary costae and intercalated costae within 1 mm of the umbo and costellae appearing in later stages of growth by branching and intercalation with counts of 3 ribs per mm, 5 mm antero-medially of the umbones of 2 pedicle valves; ventral interarea short, almost orthocline, with a narrow open delthyrium; brachial interarea not exposed.

Ventral interior with simple node-like teeth supported by long parallel dental plates extending forward for an average of one-fifth the length of 3 pedicle valves to define a narrow delthyrial chamber; muscle and mantle canal impressions unknown.

Dorsal interarea with small septalium supported by a median ridge extending forward for about one-fifth the length of the brachial valve; muscle and mantle canal impressions unknown.

FIGURED MATERIAL.

	length	width (mm)
External and internal moulds of orthocone containing impressions of 4 <i>Euorthisina</i> (BB 35377a, b)	—	—
Incomplete external and internal moulds of pedicle valve (BB 35378a, b)	4.5	—
External and internal moulds of pedicle valve (BB 35379a, b)	3.2	—
Incomplete external and internal moulds of brachial valve (BB 35380a, b)	4.5	7.5

HORIZON AND LOCALITIES. Mytton Flags: BB 35377, 35378 from the adit in Maddox's Coppice, 1200 yds ENE of St Luke's Church, Snailbeach (Grid Ref. SJ 382030); BB 35379, 35380 from outcrops by the side of the cart-track 140 yds north of Wood House, Gravels (Grid Ref. SJ 338003).

DISCUSSION. The small number of moulds of *Euorthisina* collected from the Mytton Flags include a group of 4 poorly preserved conjoined shells all orientated in the same way within an orthocone and probably buried in position of growth. The sample compares most closely with *E. moesta minor* Havlíček from the Llanvirnian Šárka Shales of Czechoslovakia, especially in the relative dimensions and size of the dental plates (cf. Pl. 28, figs. 4, 6, 7). Havlíček (1950: 87) reports that in his subspecies there are 8 to 12 ribs in the umbonal region compared with 14 to 16 in the Shelve specimens. But this difference may be an expression of variability in the older stock and its systematic importance can only be satisfactorily assessed when more material is available.

Family **PARASTROPHINIDAE** Ulrich & Cooper 1938

PARASTROPHINELLA Schuchert & Cooper 1931

Parastrophinella musculosa sp. nov.

(Pl. 28, figs. 9-13, 17)

DIAGNOSIS. Small, subtriangular, strongly biconvex *Parastrophinella* with vestigial fold and sulcus and commonly 11 to 13 costae, with a wavelength of 0.6 mm, ornamenting the anterior part of the shell.

DESCRIPTION. Small, biconvex, subtriangular *Parastrophinella* with a brachial valve averaging 93% as wide as long and 29% as deep as long (for 4 and 3 valves respectively) and a mean depth of 23% relative to the length of 3 pedicle valves, transverse profile evenly convex with steep lateral slopes, longitudinal profile evenly convex to anteriorly geniculate, dorsal fold and ventral sulcus faintly and sporadically developed; rostrate with depressed palintropes extending antero-laterally for up to 35% of the maximum width of the shell, delthyrium and notothyrium open; shell smooth for an average of 3.7 mm anterior of the umbones of 3 specimens, delayed costation consisting of rounded costae with a mean wavelength of 0.56 mm between 5 and 6 mm anterior of the umbones of 7 brachial valves and numbering 10 to 14 in 1, 2, 1, 2 and 1 brachial valves respectively between 5 and 7 mm long.

Ventral interior with small teeth and well-developed spondylium sessile posteriorly but supported anteriorly by a median septum extending forward for an average of 45% of the length of 3 pedicle valves.

Dorsal interior with subparallel outer plates separated by less than one-tenth the maximum width of the brachial valve and extending forward for a mean proportion of 40% of the length of 4 valves; elongately oval adductor scars impressed on either side of the outer plates for an average of 56% of the length of 3 valves.

TYPE MATERIAL.

		length	width (mm)
HOLOTYPE	External and internal moulds of pedicle valve (BB 35598a, b)	7.0	8.5
PARATYPES	External and internal moulds of brachial valve (BB 35599a, b)	6.0	5.8
	Internal mould of brachial valve (BB 35600)	5.0	5.2
	Internal mould of pedicle valve (BB 37107)	5.5	5.0
	Internal mould of brachial valve (BB 37108)	7.5	7.0

TYPE HORIZON AND LOCALITY. Spy Wood Grit exposed 1100 yds NNE of Rorrington (Grid Ref. SJ 303015).

DISCUSSION. The Spy Wood Grit porambonitacean is an early species of *Parastrophinella* which is like the Upper Llandeilo *P. costata* MacGregor (1961: 199) except for its significantly fewer, coarser ribs, its relatively greater length and the vestigial nature of its fold and sulcus. These differences are important enough to merit systematic recognition.

Parastrophinella sp.

(Pl. 28, figs. 14, 15)

Incomplete external and internal moulds (BB 35461a, b) of a pedicle valve, collected from the Hagley Volcanics in the roadside quarry 150 yds. north of Church Stoke Hall (Grid Ref. SO 274942), probably represent *Parastrophinella*. The valve, which was 13.5 mm long, was 85% as long as wide and 25% as deep as wide with a persistent flat-bottomed sulcus about 60% as wide as long and evenly convex flanks. Radial ornamentation consisted of rounded costae about 0.8 mm in wavelength,

5 mm antero-medially of the umbo where they arose, and numbered 4 in the sulcus and 8 on each flank. The apsacline interarea was relatively short and curved, and the open delthyrium was flanked by small teeth supported by the walls of a sessile spondylium extending anteriorly for 37% of the length of the valve.

In the absence of a complementary brachial valve, the identification of the remains of the pedicle valve as *Parastrophinella* is provisional. Furthermore, the valve is quite different from older *Parastrophinella* found in Shropshire and Wales with their weak sulci and smooth umbonal regions. More material is, therefore, required not only to indicate the specific affinities of the stock but also to verify the generic status of the specimen.

Order RHYNCHONELLIDA Kuhn 1949
 Superfamily RHYNCHONELLACEA Gray 1849
 Family TRIGONIRHYNCHIIDAE McLaren 1965
ROSTRICELLULA Ulrich & Cooper 1942

Rostricellula sparsa Williams

(Pl. 27, figs. 3, 4, 7)

1963 *Rostricellula sparsa* Williams : 467.

DIAGNOSIS. Small, relatively wide *Rostricellula* with 2 costae, averaging 0.4 mm thick 2 mm anterior of the umbo, on a well-developed fold two-fifths as wide as the length of the brachial valve, and 4 to 6 costae on each of the lateral slopes.

DESCRIPTION. Small, biconvex, subtriangular *Rostricellula* with a brachial valve slightly less long than wide (96% for 2 valves) and 15% as deep as long, and a pedicle valve slightly less than one-quarter as deep as long, dorsal fold (and ventral sulcus) strongly developed up to 40% as wide as the length of the brachial valve and rounded in transverse profile with evenly convex lateral slopes; rostrate with high curved ventral umbo and inconspicuous dorsal umbo, apical angle about 100°, nature of deltidial plates unknown; radial ornamentation exclusively costate with 2 rounded costae on the fold, averaging 0.4 mm in wavelength, 2 mm anterior of the umbones of 4 brachial valves, and 4 to 6 on the lateral slopes.

Ventral interior with small teeth supported by slightly divergent dental plates extending anteriorly for about one-eighth the length of the valve; muscle field unknown.

Hinge-plate of dorsal interior small, divided by septalium extending forward for an average of 8% the length of 4 brachial valves, median ridge low, rounded but developed for about two-fifths the length of the valve; details of crura and muscle scar unknown.

FIGURED MATERIAL.

	length	width (mm)
External and internal moulds of brachial valve (BB 35584a, b)	3.5	3.5
External and internal moulds of pedicle valve (BB 35585a, b)	3.0	—

HORIZON AND LOCALITY. Spy Wood Grit exposed 1100 yds NNE of Rorrington (Grid Ref. SJ 303015).

DISCUSSION. *Rostricellula* is rare in the Shelve area, being represented only by a few valves from the Spy Wood Grit which are quite different in ornamentation and outline from all other described species except *R. sparsa* from the Allt Ddu Mudstones of the Bala district. In every morphological aspect the Spy Wood specimens are identical with the small sample on which the Welsh species was based. Especially significant for immediate identification is the presence of 2 costae on the fold. Only one American and one European species are known with so few ribs. They are: *R. ? minuta* from the Hermitage Formation of Tennessee which, although similar in shape, has 7 or 8 costae on each lateral slope (Cooper 1956 : 640) ; and *R. ambigena* (Barrande) from the Upper Ordovician of Bohemia (Havlíček 1961 : 51) which is not only relatively longer but has the costae on the fold and sulcus branching within the size range of the British species.

Order SPIRIFERIDA Waagen 1883

Suborder ATRYPIDINA Moore 1952

Superfamily ATRYPACEA Gill 1871

Family ATRYPIDAE Gill 1871

Subfamily ZYGOSPIRINAE Waagen 1883

ZYGOSPIRA Hall 1862

Zygospira sp.

(Pl. 27, figs. 12, 13)

An internal mould (BB 37133) has been recovered from Spy Wood Grit outcrops 1100 yds NNE of Rorrington (Grid Ref. SJ 303015), which is likely to represent the remains of a brachial valve of the atrypcean *Zygospira*. The rostrate valve, which was about 2 mm long, was nearly circular in outline and about 15% as deep with a shallow narrow median sulcus and evenly convex lateral areas. The external surface was ornamented by about 15 fine costae while internally a median ridge corresponding to the narrow sulcus supported a divided hinge plate with rounded crural bases.

This occurrence is one of the earliest records of *Zygospira*, which has hitherto been described from younger Ordovician strata in N. America (Cooper 1956 : 672-674), Scotland (Williams 1962 : 242) and Mid-Europe (Havlíček & Vaněk 1966 : 61). The relatively few ribs may be diagnostic but may also reflect immaturity of the specimen and detailed comparison with established species would not be profitable at present.

VI. ACKNOWLEDGMENTS

This systematic survey could not possibly have been undertaken without the active encouragement of the late Professor W. F. Whittard, F.R.S. who so generously put his unique collection of Shelve brachiopods at my disposal and indeed sponsored

further collecting in certain localities by Mr T. R. Fry in the early stages of my researches. The study is, accordingly, dedicated to his memory; and whatever worth its comprehensiveness may have is a tribute to his inspiring devotion to Shropshire Geology.

I wish to record my thanks to Dr W. T. Dean of the Geological Survey of Canada who selflessly accepted responsibility for preparing a geological map of the Shelve area from Professor Whittard's field sheets, and for spending so much time in providing me with precise locations for nearly all the specimens in the collection. The text has greatly benefited from discussions with Dr A. D. Wright and the illustrations and statistical tables from the assistance of Dr Jean Graham, both of the Queen's University, Belfast. I am also indebted to Dr V. Havlíček for sending me specimens of *Euorthisina* and to Dr L. R. M. Cocks and Dr G. F. Elliott of the British Museum (Natural History) for their help in a number of matters relating to literature and the layout of the paper.

VII. REFERENCES

- ALICHOVA, T. N. 1953. A guide to the brachiopod fauna in the Ordovician sediments of the north-western part of the Russian Platform. *Trudy vses. nauchno-issled. geol. Inst.*, Leningrad, **1953** : 1-127, pls. 1-17. [In Russian.]
- ANDREEVA, O. N. 1960. *Novye vidy drevnikh rasteniy i Bezprovoknykh S.S.S.R.* [Markowskii, B. P., editor-in-chief], **1** : 288 pp., 73 pls. Moscow.
- BANCROFT, B. B. 1928. The Harknessellinae. *Mem. Proc. Manchr lit. phil. Soc.*, **72** : 173-196, pls. 1-2.
- 1929. Some new genera and species of Strophomenacea from the Upper Ordovician of Shropshire. *Mem. Proc. Manchr lit. phil. Soc.*, **73** : 33-65, pls. 1-2.
- 1945. The brachiopod zonal indices of the stages Costonian to Onnian in Britain. *J. Paleont.*, Menasha, **19** : 181-252, pls. 22-38.
- BARRANDE, J. 1848. *Über die Brachiopoden der Silurischen Schichten von Boehmen*, **2** : 153-256, pls. 15-23. Vienna.
- 1879. *Système Silurien du centre de la Bohême*, **5**. *Classe des Mollusques. Ordre des Brachiopodes*. 226 pp., 153 pls. Prague.
- BASSETT, D. A., WHITTINGTON, H. B. & WILLIAMS, A. 1966. The stratigraphy of the Bala district, Merionethshire. *Q. Jl geol. Soc. Lond.*, **122** : 219-271.
- BATES, D. E. B. 1968. The Lower Palaeozoic brachiopod and trilobite faunas of Anglesey. *Bull. Br. Mus. nat. Hist. (Geol.)*, London, **16** : 127-199, pls. 1-14.
- 1969. Some early Arenig brachiopods and trilobites from Wales. *Bull. Br. Mus. nat. Hist. (Geol.)*, London, **18** : 1-28, pls. 1-9.
- COCKERELL, T. D. A. 1911. The name *Glossina*. *Nautilus, Philad.*, **25** : 96.
- COOPER, G. A. 1956. Chazyan and related brachiopods. *Smithson. misc. Collns*, Washington, **127** : 1-1024, 1025-1245, pls. 1-269.
- DAVIDSON, T. 1868. British Fossil Brachiopoda, **3**. Devonian and Silurian Brachiopoda. *Palaeontogr. Soc. (Monogr.)*, London, 397 pp., 50 pls.
- 1883. Supplement to the Fossil Brachiopoda. *Palaeontogr. Soc. (Monogr.)*, London, 242 pp., 17 pls.
- DEAN, W. T. 1958. The faunal succession in the Caradoc Series of south Shropshire. *Bull. Br. Mus. nat. Hist. (Geol.)*, London, **3** : 191-231, pls. 24-26.
- GORYANSKY, V. 1969. *Inarticulate Brachiopods of the Cambro-Ordovician rock of the north-west Russian Platform*. 126 pp., 21 pls. NEDRA, Leningrad. [In Russian.]

- HAVLÍČEK, V. 1949. Orthoidea and Clitambonoidea of the Bohemian Tremadoc. *Sb. st. geol. Ust. čsl. Repub.*, Praha, **16** : 93-144, pls. 1-5.
- 1950. The Ordovician Brachiopoda from Bohemia. *Rozpr. ústřed. Ust. geol.*, Praha, **13** : 1-135, pls. 1-13.
- 1961. Rhynchonelloidea des Böhmisches Älteren Paläozoikums (Brachiopoda). *Rozpr. ústřed. Ust. geol.*, Praha, **27** : 1-211, pls. 1-27.
- 1967. Brachiopoda of the suborder Strophomenidina in Czechoslovakia. *Rozpr. ústřed. Ust. geol.*, Praha, **33** : 1-235, pls. 1-52.
- 1968. New brachiopods in the Lower Caradoc of Bohemia. *Věst. ústřed. Ust. geol.*, Praha, **43** : 123-125, pls. 1-2.
- 1970. Heterorthidae (Brachiopoda) in the Mediterranean Province. *Sb. geol. Věd. Praha*, (P) **12** : 7-39, pls. 1-11.
- 1971. Brachiopodes de l'Ordovicien du Maroc. *Notes Mém. Serv. Mines Carte géol. Maroc*, Rabat, **230** : 1-135, pls. 1-26.
- & VANĚK, J. 1966. The biostratigraphy of the Ordovician of Bohemia. *Sb. geol. Věd. Praha*, (P) **8** : 7-69, pls. 1-16.
- HOLTEDAHL, O. 1916. The Strophomenidae of the Kristiania Region. *Skr. VidenskSelsk. Christiania*, **12** : 1-117, pls. 1-16.
- JONES, O. T. 1928. *Plectambonites* and some allied genera. *Mem. geol. Surv. Gr. Br. Palaeont.*, London, **1** (5) : 367-527, pls. 21-25.
- KOZŁOWSKI, R. 1929. Les brachiopodes gothlandiens de la Podolie Polonaise. *Palaeont. pol.*, Warsaw, **1** : 1-254, pls. 1-12.
- LAPWORTH, C. & WATTS, W. W. 1894. The geology of South Shropshire. *Proc. Geol. Ass.*, London, **13** : 297-355, pls. 8-9.
- MACGREGOR, A. R. 1961. Upper Llandeilo brachiopods from the Berwyn Hills, North Wales. *Palaeontology*, London, **4** : 177-209, pls. 19-23.
- MICKWITZ, A. 1909. Vorläufige Mitteilung über das Genus *Pseudolingula* Mickwitz. *Mém. Acad. Sci. St. Petersb.* (6) **3** : 765-772.
- MURCHISON, R. I. 1839. *The Silurian System* [&c.]. 768 pp., 37 pls. London.
- 1859. *Siluria*. 3rd ed. 592 pp., 42 pls. London.
- NEUMAN, R. B. 1964. Fossils in Ordovician tuffs, Northeastern Maine. *Bull. U.S. geol. Surv.*, Washington, **1181-E** : 1-38, pls. 1-7.
- 1968. Paleogeographic implications of Ordovician shelly fossils in the Magog belt of the Northern Appalachian Region. In Zen, E-an, et al. (eds). *Studies of Appalachian Geology: Northern and Maritime* : 35-48, pls. New York.
- NIKIFOROVA, O. I. & ANDREEVA, O. N. 1961. Ordovician and Silurian stratigraphy of the Siberian Platform and its palaeontological basis (Brachiopoda). *Trudy vses. nauchno-issled. geol. Inst.*, Leningrad, **56** : 1-412, pls. 1-56. [In Russian.]
- ÕPIK, A. 1930. Brachiopoda Protremata der Estländischen Ordovizischen Kukruse-Stufe. *Tartu Ulik. Geol.-Inst. Toim.*, **20** : 1-261, pls. 1-22.
- 1934. Über Klitamboniten. *Tartu Ulik. Geol.-Inst. Toim.*, **39** : 1-239, pls. 1-48.
- 1939. Brachiopoden und Ostrakoden aus dem Expansusschiefer Norwegens. *Norsk geol. Tidsskr.*, Oslo, **19** : 117-142, pls. 1-6.
- PHILLIPS, J. 1848. The Malvern Hills, compared with the Palaeozoic districts of Abberley, Woolhope, May Hill, Tortworth and Usk. *Mem. geol. Surv. U.K.*, London, **2** : 1-330, pls. 1-3.
- RÕDMUSOKS, A. K. 1959. Strophomenoidea Ordovika i Silura Estonii 1. Rod *Sowerbyella* Jones. *Tartu Univ. (Dorpat), Act. Commentationes* **75** : 11-41, pls. 1-8.
- 1970. *Stratigraphy of the Viruan Series (Middle Ordovician) in Northern Estonia*. Tallin, U.S.S.R. 345 pp., 8 pls. [In Russian.]
- ROWELL, A. J. 1966. Revision of some Cambrian and Ordovician inarticulate brachiopods. *Paleont. Contr. Univ. Kans.*, Topeka, **7** : 1-36, pls. 1-4.

- RUBEL, M. P. 1961. Lower Ordovician brachiopods of the superfamilies Orthacea, Dalmanellacea and Syntrophiacea of the eastern Baltic. *Eesti NSV Tead. Akad. geol. Inst. Uurimused*, **6**: 141-226, pls. 1-27. [In Russian.]
- RUDWICK, M. J. S. 1965. Sensory spines in the Jurassic brachiopod *Acanthothiris*. *Palaeontology*, London, **8**: 604-617, pls. 84-87.
- SALTER, J. W. 1859. Appendix A. In Murchison, R. I. *Siluria*, 3rd ed.: 531-552. London.
- 1866. Appendix. On the fossils of North Wales. In Ramsey, A. C. *The Geology of North Wales*. *Mem. geol. Surv. U.K.*, London, **3**: 239-381, pls. 1-26.
- SCHUCHERT, C. & COOPER, G. A. 1932. Brachiopod genera of the suborders Orthoidea and Pentameroidea. *Mem. Peabody Mus. Yale*, New Haven, **4**: 1-270, pls. 1-29.
- SINCLAIR, G. W. 1945. Some Ordovician Lingulid Brachiopods. *Trans. R. Soc. Can.*, Ottawa, (3, iv) **39**: 55-82, pls. 1-4.
- SOWERBY, J. DE C. 1839. In Murchison, R. I. *The Silurian System* [&c.]: 608-644, pls. 5-22. London.
- SPJELDNAES, N. 1957. The Middle Ordovician of the Oslo Region, Norway. 8. Brachiopods of the Suborder Strophomenida. *Norsk geol. Tidsskr.*, Bergen, **37**: 1-214, pls. 1-14.
- TEMPLE, J. T. 1968. The Lower Llandovery (Silurian) brachiopods from Keisley, Westmorland. *Palaeontogr. Soc. (Monogr.)*, London, 58 pp., 10 pls.
- 1970. The Lower Llandovery brachiopods and trilobites from Ffridd Mathrafal, near Meifod, Montgomeryshire. *Palaeontogr. Soc. (Monogr.)*, London, 76 pp., 19 pls.
- ULRICH E. O. & COOPER, G. A. 1936. New genera and species of Ozarkian and Canadian brachiopods. *J. Paleont.*, Tulsa, **10**: 616-631.
- 1938. Ozarkian and Canadian Brachiopoda. *Spec. Pap. geol. Soc. Am.*, Baltimore, **13**: 1-323, pls. 1-58.
- WATTS, W. W. 1925. The geology of South Shropshire. *Proc. Geol. Ass.*, London, **36**: 321-363.
- WHITTARD, W. F. 1952. A geology of South Shropshire. *Proc. Geol. Ass.*, London, **63**: 143-197.
- 1966. The trilobites of the Henllan Ash (Lower Ordovician), Merionethshire. *Bull. Br. Mus. nat. Hist. (Geol.)*, London, **11**: 489-505, pls. 1-5.
- WHITTINGTON, H. B. & WILLIAMS, A. 1955. The fauna of the Derfel Limestone of the Arenig District, North Wales. *Phil. Trans. R. Soc.*, London, (B) **238**: 397-430, pls. 38-40.
- WILLIAMS, A. 1949. New Lower Ordovician brachiopods from the Llandeilo-Llangadock District. *Geol. Mag.*, London, **86**: 161-174, 226-238, pls. 8, 11.
- 1953. The geology of the Llandeilo district, Carmarthenshire. *Q. Jl geol. Soc. Lond.*, **108**: 177-208.
- 1962. The stratigraphy and brachiopod faunas of the Barr and Lower Ardmillan Series (Caradoc) of the Girvan district, south-west Ayrshire, with descriptions of the Brachiopoda. *Mem. geol. Soc. Lond.*, **3**: 1-267, pls. 1-25.
- 1963. The Caradocian brachiopod faunas of the Bala District, Merionethshire. *Bull. Br. Mus. nat. Hist. (Geol.)*, London, **8**: 327-471, pls. 1-16.
- 1973. Distribution of brachiopod assemblages in relation to Ordovician palaeogeography. In Hughes, N. F. (ed.). *Organisms and Continents through Time*. *Spec. Pap. Palaeont.*, London, **12**: 241-269.
- *et al.* 1965. Brachiopoda. In Moore, R. C. (ed.). *Treatise on Invertebrate Paleontology*, H. 927 pp., illustr. Kansas.
- *et al.* 1972. A correlation of Ordovician rocks in the British Isles. *Spec. Rep. geol. Soc. Lond.*, **3**: 1-74, text-figs.
- WILSON, A. E. 1913. A new brachiopod from the base of the Utica. *Bull. Victoria meml Mus.*, Ottawa, **1**: 81-84, pl. 8.
- WRIGHT, A. D. 1963. The fauna of the Portrane Limestone. I. The inarticulate brachiopods. *Bull. Br. Mus. nat. Hist. (Geol.)*, London, **8**: 221-254, pls. 1-4.

- 1964. The fauna of the Portrane Limestone, II. *Bull. Br. Mus. nat. Hist. (Geol.)*, London, **9**: 157-256, pls. I-11.
- 1971. Taxonomic significance of the pseudodeltidium in triplésiacean brachiopods. *Palaeontology*, London, **14**: 342-356, pls. 62-63.

INDEX

New taxonomic names and the page numbers of the principal references are printed in **bold** type. An asterisk (*) denotes a figure.

- Acanthothiris* 55
 Acrotretacea 42-4
 Acrotretida 42-9
 Acrotretidae 42-4
 Acrotretidina 42-8
 Actonian 14
 Addison, R. 14, 124
 Aegiromeninae 139-40
 Africa, North 11, 13; see Morocco
 Address Shales 9-11, 12*, 14, 15*, 21, **22**
Alimbella 68-9
 Alimbellidae **68**, 69-71
 Allt Dhu Mudstones 14
 Anglesey 12, 14
 Anglo-Welsh successions 8, 11, 13, 16
 Anomalorthinae 115
Apsotreta 42
 sp. 9, 17, **42-3**; pl. 6, figs. 14-5
 Arenig 11-2, 14, 15*, 18
 Articulata 49-154
Astraborthis 7, **68-9**, 69*
 unicapata 9, 17, 69, **70-1**; pl. 11, figs. 5, 6, 9, 11, 14
 Atrypacea 154
 Atrypidae 154
 Atrypidina 154
- Bala 14
 Balclatchie Mudstones 11
 Baltic 11
 Berwyn Dome 13
 Betton Beds 9-13, 12*, 15*, **19**
Bicuspina 13-5, 21-3, 117, 124, 126
 cava 119
 modesta 9, 20-1, **118-21**; pl. 20, figs. 3-8
 multicostellata 119
 spiriferoides 119
 subquadrata 9, 22-3, **117-8**, 119-21; pl. 19, figs. 17-9; pl. 20, figs. 1-2
 Bohemia 8, 11, 13-4, 16; see Czechoslovakia
 brachiopoda 1-158
- Bystromena** 7, 21, **145-6**, 147*, 148
 perplexa 9, 21, **146-8**; pl. 25, fig. 14; pl. 26, figs. 3-14; pl. 27, figs. 1-2
- Caeroplecia** 7, 14, 22, **121**, 122*
 plicata 9, 22-3, 121, **122-4**; pl. 20, figs. 14-6; pl. 21, figs. 1-6, 8
 Caradoc 13-6, 15*
 Carlisle, Mrs. H. 65
 Carmarthenshire 12, 14
 Cautleyan 14
 'Cliftonia' *dorsata* 126
 Clitambonitidina 115-6
 Cocks, Dr L. R. M. 155
 commonness, relative, of species 16
Conotreta 43
 stapeleyensis 9, 18, **43-4**; pl. 6, figs. 16-21
 continental plates, ancient 8
 Coston Beds, Costonian 14, 15*, 16
 Craniacea 48-9
 Craniidae 48-9
 Craniidina 48-9
 currents, transporting capacity 16
 Czechoslovakia 11, 13, 16; see Bohemia
- Dalmanella* 13-5, 18-9, 21-2, 89
 elementaria 9, 17, **97-8**; pl. 16, figs. 2-8
 indica 93
 parva **89-90**, 92-7; pl. 15, figs. 1-4, 7
 prototypa 108
 salopiensis 9, 19-20, **90-1**, 92-7; pl. 15, figs. 5-6, 8-12
 gregaria 9, 21, **91-2**, 93-7; pl. 15, figs. 13-6, 20
 transversa 9, 22, **92-3**, 93-7; pl. 15, figs. 17-9, 21-4; pl. 16, fig. 1
- Dalmanellidae 89-102
 Dean, Dr W. T. 8, 155
 Derfel Limestone 14
Desmorthis 11, 18, 73
 ? sp. nov. 9, 17-8, **73-4**; pl. 12, figs. 2-4, 8
Didymograptus bifidus zone, shales 13, 110

- murchisoni* zone 12
Dinorthis 23
Diparelasma 11, 71
 sp. 9, 17, **71**; pl. 11, figs. 3, 7-8
 Discinacea 44-8
 Discinidae 11, 47-8
 Dolerorthidae 63-7
 Dolerorthinae 63-4
Dolerorthis 63
 cf. *tenuicostata* 9, 14, 23, **63-4**; pl. 10,
 figs. 3, 5, 7, 10, 13
Drabovia 15, 87
 cf. *fascicostata* 9, 16, 21, **87-8**; pl. 14,
 figs. 14-6, 18-9
 fascicostatata 87
 Draboviinae 87-9
- Elkaniidae 38-40
 Elliott, Dr G. F. 155
 Enteletacea 87-115
 environments 16, 18
Eocramatia 7, 127-8, **128-9**, 129*
 dissimulata 9, 18, **129-30**; pl. 21, figs.
 9, 12, 14-5; pl. 22, figs. 1-3, 5-6
Eocramatiidae 7, **127-8**, 128-30
Euorthisina 11, 18, **150**, 155
 moesta 150; pl. 28, figs. 4, 6-7
 cf. *moesta minor* 9, 11, 17, **150-1**; pl. 28,
 figs. 1-3, 5, 8.
expansus shale 115
- faunal associations 16-23
 distribution 9-16
 Ffairfach Grit, Group 13
Finkelburgia 85
 Finkelburgiidae 68, 71-85
 Fry, T. R. 8, 155
Furcitella 140-1
 plicata 141
 sp. 9, 23, **140-1**; pl. 25, figs. 4-5
 Furcitellinae 140-1
- Garn-Wen 13
Gelidorthis 74
 cf. *partita* 9, 13, 20, **74-5**; pl. 12, figs.
 5-7
 Gelli-Grin Calcareous Ashes 14, 58
Givaldiella partita 74
 Glossellinae 35-8
Glossina 31
Glossorthis 68
Glyptoglossella 30
 Glyptomeninae 145-8
 Glyptorthisinae 64-7
- Glyptorthis* 14, 21, 64
 assimilis 65
 balclatchiensis 65
 crispa 65
 nantensis 65
 viriosa 10, 20-1, 23, **64-7**; pl. 10, figs. 6,
 8-9, 11-2, 14-5; pl. 11, figs. 1-2, 4
 sp. 20
 Gonambonitacea 115-6
 Gonambonitidae 115
 Graham, Dr Jean 155
 graptolites 8, 13; see *Didymograptus*
- Hagley Shales 9-11, 12*, 14, 15*, 21, **22**
 Volcanic Group 15*
Harknessella 102
 cf. *subplicata* 10, 14, 21, **102**; pl. 16,
 fig. 16
 Harknessellidae 102-6
 Harnagian 14, 15*
 Havlíček, Dr V. 155
Hedstroemina 145
 holtedahli 145
 robusta 145
 Henllan Ashes 12
Hesperonomia 11, 49
 australis 50
 sp. 10, 12, 17, **49-50**; pl. 7, figs. 9, 12
Hesperonomiella 12, 50
 carmalensis 50
 Hesperonomiidae 49-50
 Heterorthisidae 106-14
Heterorthis 13-4, 106-7
 retrovristria 107
 sp. 10, 20-2, **106-7**; pl. 17, figs. 10-4
 Hope Shales 9-11, 12*, 15*, **18**
Hordeleyella 13-4, 102
 convexa 104
 plicata 103
 cf. *plicata* 10, 14, 21-2, **102-3**; pl. 16,
 figs. 17, 19-20; pl. 17, fig. 1
 subcarinata 103
 sp. 10, 20, **104**; pl. 17, figs. 2-3
- Inarticulata 13, 25-49
 invertebrates 8
- Kiaeromena* 149
 cf. *kjerulfi* 10, 14, **149-50**; pl. 27, figs. 6,
 10-1
 sp. 22-3
Kjaerina (*Hedstroemina*) 145
 sp. 10, 21, **145**; pl. 26, fig. 2

- Ktaoua Formation, Morocco 14
Kullervo 115
 panderi 116
 sp. 10, 20, **115-6**; pl. 19, figs. 14-5
 Kullervoidae 115-6
- lahars 21
Lenorthis 18, 52
 parvicrassicostatus 53
 proava 12, 53-4
 cf. *proava* 10-1, 17, **52-3**, 55-7; pl. 8,
 figs. 2-9
Leptaena 23, 148
 kjerulfi 149
 sericea 134
 cf. *ventricosa* 10, 14, 22-3, **148-9**; pl. 27,
 figs. 5, 8-9
 Leptaenidae 148-50
 Leptestiidae 126-7
 Leptestiinae 126-7
 Letná Formation, Bohemia 15-6, 88
 Libeň Formation, Bohemia 15
Lingula 19
 attenuata 31-2
 plumbea 38
 Lingulacea 25-42
Lingulella 12, 18, 28, 31
 decorticata 31
 displosa 10, 19-20, **28-9**; pl. 2, figs. 2-8
 petila 10, 18, **29-31**; pl. 2, figs. 9-11;
 pl. 3, fig. 1
 lingulaeformis 31
 rideanensis 31
 Lingulellinae 28-35
 Lingulida 25-42
 Linoporellidae 114-5
 Llandeilo 12-3, 15*, 16
 Flags 13
 Llandoverly 16
 Llanvirn 11-2, 15*, 19
 Longvillian 14
- Macrocoelia llandeiloensis* 13
Mcewanella 78-81
 berwynensis 79
 sp. 10, 23, **78-9**; pl. 13, figs. 3, 5
 Meadowtown Beds 9-11, 12*, 13-4, 15*,
 19, 20, 21
Medesia 68-9
Monobolina 18-9, 38
 plumbea 10, 12, 17, 38-40; pl. 5, figs.
 2-10; pl. 6, fig. 1
 Morocco 8, 11, 13-4
- Murinella* 141
 partita 141
 sp. 10, 20, **141**; pl. 25, figs. 2-3
 Mytton Flags 9-11, 12*, 15*, 16, 17, 18
- Nant Hir Mudstones 14
Nicolella 14, 22, 57
 cf. *actoniae* 10, 14, 22-3, **57-60**; pl. 9,
 figs. 1-6
 actoniae obesa 58-9
Nocturniella 88
 nocturna 89
 sp. 10-1, 17, **88-9**; pl. 14, figs. 17, 20
- Obolidae 11, 25-38
 Obolinae 25-8
Obolus 18, 25
 ? *biconvexa* 26
 ? *nitens* 26
 subditivus 10, 18, **25-6**; pl. 1, figs. 1-8
 sp. 10, 17, **26**; pl. 1, figs. 9-10
Onniella 15, 21-2, 98
 ostentata 98-9
 lepida 10, 14, 22-3, **98-102**; pl. 16,
 figs. 9-14
 soudleyensis 99
 sp. 10, 21, 99; pl. 16, figs. 15, 18
- Onychoplecia* 126
Orbiculoidea 47-8
 sp. 10, **47**; pl. 7, fig. 1
 Orbiculoideinae 47-8
 Ordovician 1-158
 Orthacea, orthaceans 7, 49-86
Orthambonites 22, 24*, 53
 bellus 54
 calligramma 53, 55
 exopunctata 10, 23, **53-7**; pl. 8, figs.
 10-7
 friendsvillensis 54
 orbicularis 53
 playfairi 54
 cf. *rotundiformis* 55
 sp. 10, 22
- Orthida 49-126
 Orthidae 50-63, 68
 Orthidina 49-115
 Orthinae 50-7
Orthis 18, 50
 actoniae 57
 cf. *callactis* 10-1, 17, **50-1**; pl. 7, figs.
 10-1, 13-6
 calligramma 53
 proava 52

- Carausii* 52
panderiana 53
partita 74
 sp. 10, 18, **51**; pl. 8, fig. 1
Oxogonites 11, 115
costellatus 115
 ? sp. 10, 17, **115**; pl. 19, figs. 12-3
Oxoplecia **124**, 126
costellata 125
dorsata 126
gibbosa 123
mutabilis 123
nantensis 125-6
 cf. *nantensis* 10, 13, 20, **125-6**; pl. 20,
 figs. 9-13
pennsylvanica 123
sibirica 125
- palaeoecology 16, 23
 palaeogeography 8
Palaeoglossa 12, 18-9, 21, **31-2**
attenuata 10, 19-23, **32-3**, 34-5; pl. 3,
 figs. 2-13
myttonensis 10, 16-7, **33-5**; pl. 4,
 figs. 1-5
Palaeostrophomena 14, 22, 126
magnifica 127
 sp. 10, 23, **126-7**; pl. 21, figs. 7,
 10-1, 13
Parastrophinella 151
costata 152
musculosa 10, 21, **151-2**; pl. 28, figs.
 9-13, 17
 sp. 10, 22, **152-3**; pl. 28, figs. 14-5
 Parastrophinidae 151-3
Paterula 11, 18-9, 21, 40
 cf. *bohemica* 10, 17-20, **40-1**, 42; pl. 6,
 figs. 2-11
 cf. *perfecta* 10, 21-2, **41-2**; pl. 6, figs.
 12-3
 Paterulidae 40-2
Paworthis 108
 Pembrokeshire 14
 Pentamerida 150-3
Petrocrania 48
dubia 10, 22-3, **48-9**; pl. 7, figs. 5-6, 8
inexpectata 49
Platymena 143, 146
Platystrophia 14, 22, 68, 76, 79-81
caelata 10, 22-3, **76-7**, 78; pl. 12, figs.
 13-4, 16-9
chama 77
dentata 78
- cf. *major* 10, 14, 21-2, **78**; pl. 13, figs.
 1-2, 4
precedens 78
major 78
 Platystrophiinae 68, 76-81
 Plectambonitacea, plectambonitaceans 7,
 126-40
 Plectorthidae 68, 71-81
 Plectorthinae 71-6
Plectorthis 71
whitteryensis 10, 22-3, **71-3**; pl. 11,
 figs. 10, 13, 16-7; pl. 12, fig. 1
 sp. 10, 22, **73**; pl. 11, figs. 12, 15
Plesiomys (Retrosistria) 61
 Porambonitacea 68, 150-3
 Portrane Limestone 14
 Productorthinae 57-60
Protoskenidioides 7, 18, **83-5**, 84*
revelata 10, 16-7, 83, **85-6**; pl. 14, figs.
 4-13
Pseudobolus 31
Pseudolingula 12, 18-9, **35**, 36*
quadrata 38
spatula 10, 17-20, **36-8**; pl. 4, figs.
 6-14; pl. 5, fig. 1
 sp. 11
- Rafinesquina* 19, 21, 141-3
delicata 10, 13, 19-20, **141-3**, 144-5;
 pl. 25, figs. 6-13
expansa 143
simplex 143
 sp. 10, 20, 22-3, **143**; pl. 25, fig. 1;
 pl. 26, fig. 1
 Rafinesquininae 141-5
Resserella immatura 109
Retrosistria 61
Reuschella 14-5, 22, 104
hordeverleyensis 105
carinata 10, 22-3, **104-6**; pl. 17,
 figs. 4-9
undulata 105
 Rhynchonellacea 153-4
 Rhynchonellida 153-4
 Rorrington Beds 9-11, 12*, 13, 15*, 16, 19,
20
Rostricellula 153
ambigua 154
 ? *minuta* 154
sparsa 10, 21, **153-4**; pl. 27, figs. 3-4, 7
- Salacorthis** 7, 14, **79-80**, 81*
costellata 10, 21, 79, **80-1**; pl. 13,
 figs. 6-13

- Salopia* 14, 114
salteri 114-5
 cf. *salteri* 10, 14, 21, **114**; pl. 19, figs. 10-1
 sp. 10, 22-3, **114-5**; pl. 19, figs. 6-9
 Šárka Formation, Bohemia 11, 42, 152
- Schizocrania* 12, 18-9, 21, 44
filosa 46
salopiensis 10, 18-21, **44-6**; pl. 6,
 figs. 22-6
- Schizophoriidae 87-9
- Schizotreta* 47
elliptica 48
microthyris 48
transversa 10, 20, **47-8**; pl. 7, figs. 2-3, 7
 sp. 10, 17-9, **48**; pl. 7, fig. 4
- Schmidtites* 18-9, 21, 26
 ? **simplex** 11, 20, 22, **26-7**, 28; pl. 1,
 figs. 11-5
subcircularis 11, 17-8, **27-8**; pl. 1,
 figs. 16-7; pl. 2, fig. 1
- Scotland 11
- Sericoidea* 22, 139-40
abdita 140
 cf. *abdita* 11, 22, **139-40**; pl. 24, figs.
 8-9, 12, 15, 17-8; pl. 28, fig. 16
 aff. *abdita* 140
- Shelve District, Shropshire 1-158
- Shropshire 1-158
- Skenidiidae 82-6
- Skenidioides* 13, 82-3, 85
 cf. *costatus* 11, 14, 20-1, 23, **82-3**, 85;
 pl. 13, figs. 14-6; pl. 14, figs. 1-3
- Soudleyan 14, 15*
- Sowerbyella* 13-4, 21-2, 130, 136
antiqua 13, **130-1**, 132, 135-9; pl. 22,
 figs. 4, 7-14; pl. 23, figs. 1, 3-4
 cf. *antiqua* 11, 20, **131-2**, 137-9; pl. 23,
 figs. 2, 5-13
multiseptata 11, 21, **132-3**, 135-9; pl.
 23, figs. 14-9; pl. 24, figs. 1, 3
sericea 136
 cf. *sericea* 11, 14, 22-3, **134-9**; pl. 24,
 figs. 11, 13-4, 16
permixta 11, 14, 22, **133-4**, 136-9; pl.
 24, figs. 2, 4-7, 10
 sp. 11, 20
- Sowerbyellidae 130-40
- Sowerbyellinae 130-9
- Spiriferida 154
- Spy Wood Grit 7, 9-11, 12*, 13-4, 15*,
 16, **21**
- Stapeley Shales, Volcanic Group 9-11, 12*,
 15*, **18**
- statistical tests 23-4
- Stiperstones Quartzite 11, 15*
- Strachan, Dr I. 8, 12
- Strophomenacea, strophomenaceans 7, 140-
 50
- Strophomenida 126-50
- Strophomenidae 140-8
- Strophomenidina 126-50
- subduction zones 8
- Syntrophiidae 150-1
- Syntrophiidina 150-3
- systematic methods 23-5
- Tachilla Shales, Morocco 11
- Tazzarinia* 13, 75
drotae 76
elongata 11, 20, **75-6**; pl. 12, figs.
 9-12, 15
foraminosa 76
- Tissintia* 13, 19, **107-8**
immatura 11, 13, 20, **109-14**; pl. 18,
 figs. 10, 12-5; pl. 19, figs. 1-5
plana 13
prototypa 11-3, 19, 107, **108-9**, 111-4;
 pl. 17, figs. 15-9; pl. 18, figs. 1-9, 11
- Trematidae 44-6
- Trigonirhynchiidae 153-4
- trilobites 8, 13, 16
- Triplesia* 116
deformata 117
simplex 117
subcarinata 117
 sp. 11, 23, **116-7**; pl. 19, fig. 16
- Triplesiacea, triplesiaceans 7, 116-26
- Triplesiidae 116-26
- Triplesiidina 116-26
- Viruella* 135
- Wales 7, 11
 successions 12-3
- Weston Beds 9-12, 12*, 15*, **19**
- Whittard, Professor W. F. 8, 62, 154
- Whittardia** 7, 22, 60-1, 61*, **62**
paradoxa 11, 23, **62-3**; pl. 9, figs.
 7-15; pl. 10, figs. 1-2, 4
- Whittardiinae** 7, **60-1**, 62-3
- Whittery Shales 7, 9-11, 12*, 14, 15*,
 21-2, **23**
 Volcanic Group 15*, 21

Wright, Dr A. D. 155

Xenelasma 150

Xenelasmatinae 150-1

Zahorány Formation, Bohemia 15, 49

Zygospira 154

sp. 11, 21, **154**; pl. 27, figs. 12-3

Zygospirinae 154

Professor ALWYN WILLIAMS, Ph.D., F.G.S., M.R.I.A., F.R.S.E., F.R.S.

Department of Geology

THE UNIVERSITY OF BIRMINGHAM

P.O. Box 363

BIRMINGHAM B15 2TT

Accepted for publication 1 February 1974

PLATE 1

Obolus subditivus sp. nov. (p. 25)

Hope Shales, near Brithdir Farm, Shropshire.

FIGS. 1, 3, 2. Holotype, BB 35573a, b. Latex casts of the exterior and interior and the internal mould of a pedicle valve, $\times 5.6$.

FIGS. 5, 6. Paratype, BB 35574a, b. Latex cast of the exterior and the internal mould of a pedicle valve, $\times 6.3$, $\times 5.8$.

FIGS. 4, 8, 7. Paratype, BB 35575a, b. Latex casts of the exterior and interior and the internal mould of a brachial valve, $\times 5.5$.

Obolus sp. (p. 26)

Mytton Flags, Bergam Quarry, Shropshire.

FIG. 9. BB 35581a. Exfoliated pedicle valve, $\times 4.3$.

Mytton Flags, near Wood House, Shropshire.

FIG. 10. BB 35582. Exfoliated brachial valve, $\times 4.5$.

Schmidtites ? simplex sp. nov. (p. 26)

Rorrington Beds, Holywell Brook, Shropshire.

FIG. 11. Holotype, BB 37134a. Internal mould of a pedicle valve, $\times 8$.

FIG. 14. Paratype, BB 37138. Internal mould of a brachial valve, $\times 6.7$.

Rorrington Beds, Deadman's Dingle, Shropshire.

FIG. 12. Paratype, BB 37139. Internal mould of a pedicle valve, $\times 8$.

Rorrington Beds, near the Mount, Shropshire.

FIG. 13. Paratype, BB 37136. Exterior of a pedicle valve, $\times 9$.

Rorrington Beds, near Desert, Shropshire.

FIG. 15. Paratype, BB 37140a. Internal mould of a pedicle valve, $\times 8.3$.

Schmidtites ? simplex subcircularis sp. et subsp. nov. (p. 27)

Stapeley Shales, Whitsburn Dingle, Shropshire.

FIG. 16. Holotype, BB 37141. Exterior of a pedicle valve, $\times 9.2$.

FIG. 17. Paratype, BB 37142b. Latex cast of the external mould of a pedicle valve, $\times 8$.

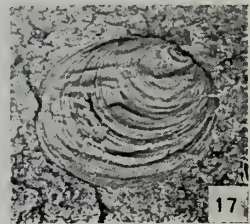
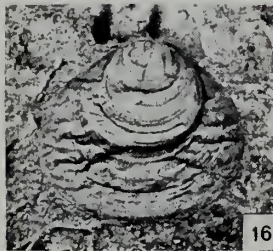
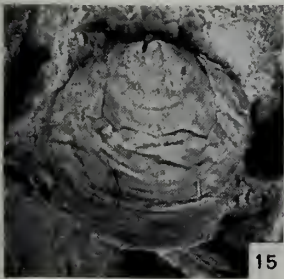
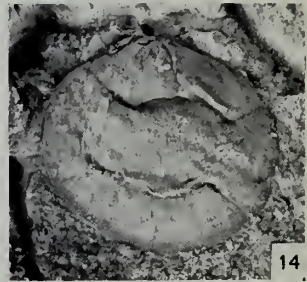
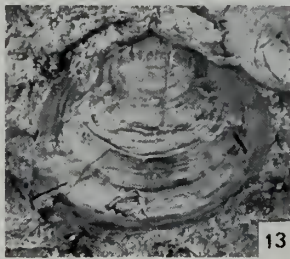
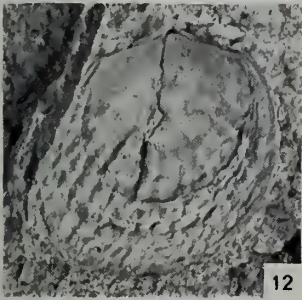
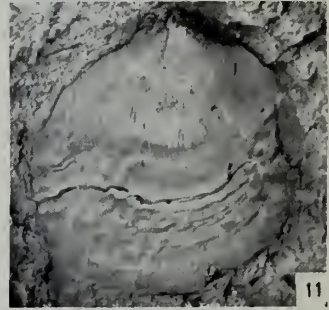
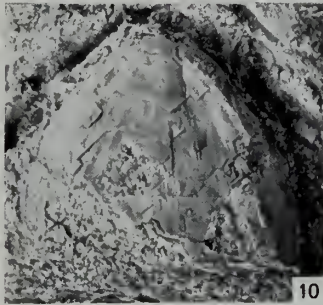
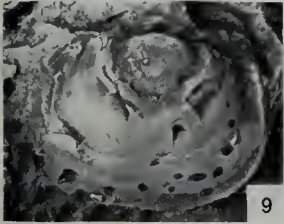
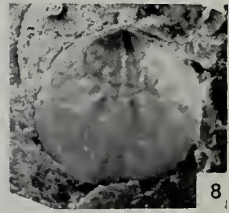
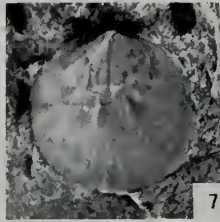
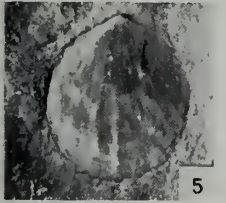
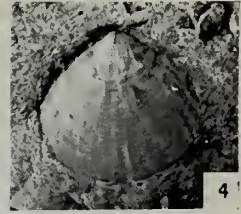
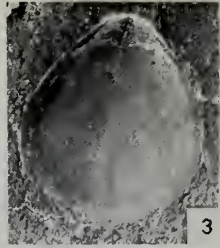
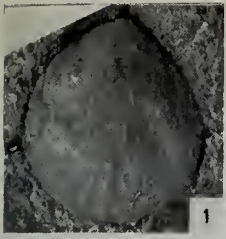


PLATE 2

Schmidites ? simplex subcircularis sp. et subsp. nov. (p. 27)

Stapeley Shales, Whitsburn Dingle, Shropshire.

FIG. 1. Paratype, BB 37143a. Internal mould of a brachial valve, $\times 6$.

Lingulella displosa sp. nov. (p. 28)

Meadowtown Beds, Waitchley, Shropshire.

FIG. 2. Paratype, BB 37146a. Internal mould of a pedicle valve, $\times 3.8$.

Meadowtown Beds, near Meadowtown Quarry, Shropshire.

FIGS. 4, 3, 8. Holotype, BB 37144a, b. Latex cast, with detail, of the external mould, and the internal mould of a pedicle valve, $\times 4$, $\times 12$, $\times 3$.

Rorrington Beds, Lower Wood Brook, Shropshire.

FIG. 5. Paratype, BB 37149. Internal mould of a brachial valve, $\times 2.8$.

Meadowtown Beds, Little Weston, Shropshire.

FIG. 6. Paratype, BB 37148a. Internal mould of a pedicle valve, $\times 3.1$.

Meadowtown Beds, near Meadowtown Quarry, Shropshire.

FIG. 7. Paratype, BB 37147a. Internal mould of a brachial valve, $\times 3$.

Lingulella displosa petila sp. et subsp. nov. (p. 29)

Stapeley Volcanic Group, Whitsburn Dingle, Shropshire.

FIG. 9. Paratype, BB 37152a. Internal mould of a pedicle valve, $\times 4$.

FIG. 10. Paratype, BB 37151a. Internal mould of a brachial valve, $\times 4$.

FIG. 11. Holotype, BB 37150b. Latex cast of the external mould of a pedicle valve, $\times 9$.

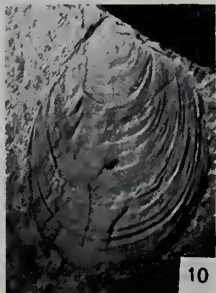
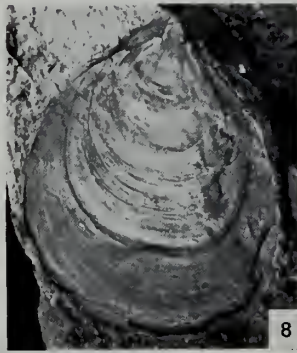
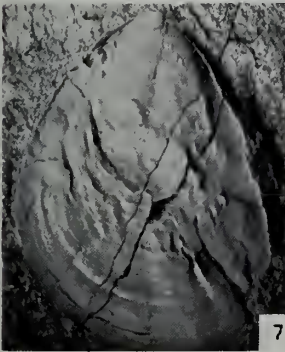
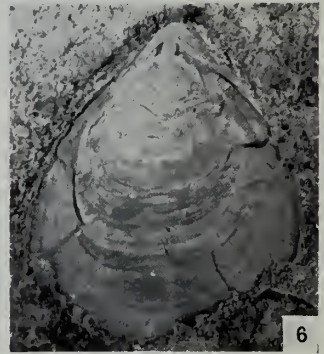
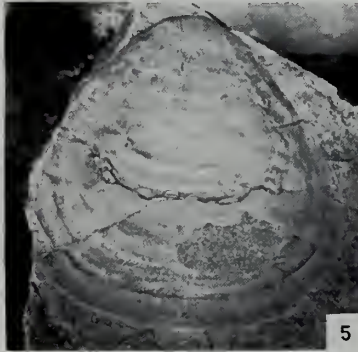
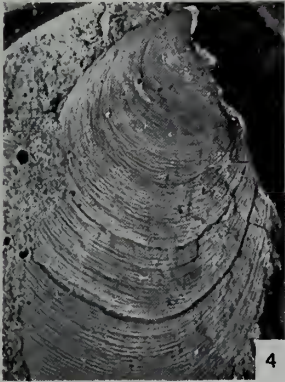
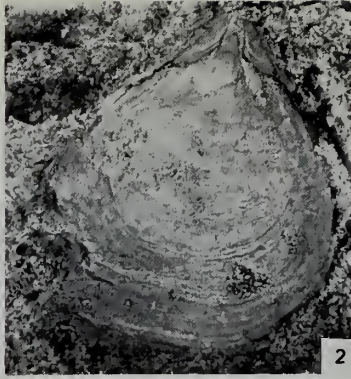
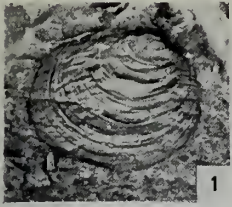


PLATE 3

Lingulella displosa petila sp. et subsp. nov. (p. 29)

Stapeley Volcanic Group, Whitsburn Dingle, Shropshire.

FIG. 1. Holotype, BB 37150a. Internal mould of a pedicle valve, $\times 4.5$.

Palaeoglossa attenuata (J. de C. Sowerby) (p. 32)

Meadowtown Beds, Lower Wood Brook, Shropshire.

FIG. 2. BB 37109a. Internal mould of a brachial valve, $\times 3.4$.

Meadowtown Beds, Little Weston, Shropshire.

FIG. 3. BB 37110a. Internal mould of a pedicle valve, $\times 5$.

Betton Beds, near junction of Holywell and Whitehouse Brooks, Shropshire.

FIGS. 4, 11. BB 37117a, b. Internal moulds of pedicle and brachial valves, $\times 6.5$, $\times 6.9$.

FIG. 12. BB 37116a. Internal mould of a pedicle valve, $\times 4.7$.

Meadowtown Beds, near Meadowtown Quarry, Shropshire.

FIGS. 7, 5. BB 37113. Exterior, with detail, of a pedicle valve, $\times 6.5$, $\times 13$.

FIG. 8. BB 37115. Internal mould of a pedicle valve, $\times 2.8$.

Meadowtown Beds, near Meadowtown Chapel, Shropshire.

FIG. 6. BB 37111a. Internal mould of a ventral pseudointerarea, $\times 17.3$.

FIG. 9. BB 37112. Latex cast of the exterior of a pedicle valve, $\times 4.6$.

FIG. 10. BB 37114a. Internal mould of a brachial valve, $\times 5.4$.

Rorrington Beds, in stream near Meadowtown Chapel, Shropshire.

FIG. 13. BB 37118b. Internal mould of a brachial valve, $\times 3.5$.

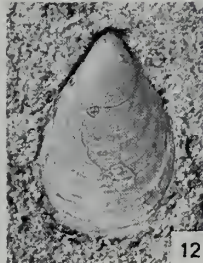
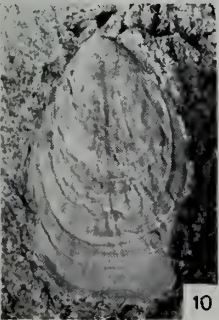
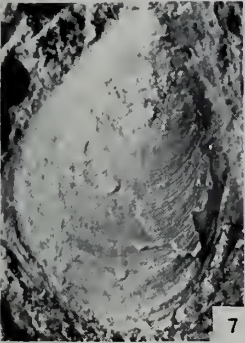
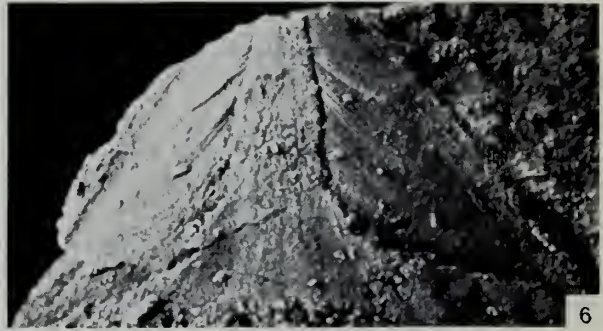
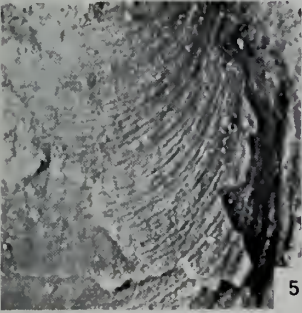
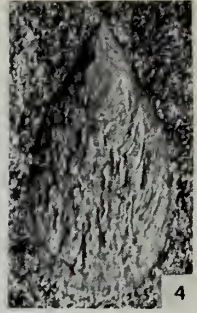
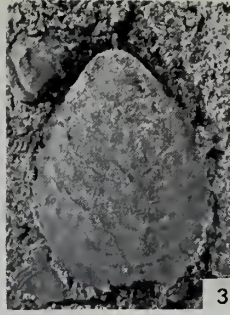


PLATE 4

Palaeoglossa myttonensis sp. nov. (p. 33)

Mytton Flags, Whitegrit School, Shropshire.

FIGS. 2, 1. Paratype, BB 37122a, b. External and internal moulds of disarticulated valves, $\times 4.9$, $\times 5.8$.

FIG. 4. Holotype, BB 37119. Internal mould of a pedicle valve and an external mould of the complementary brachial valve, $\times 4.9$.

Mytton Flags, near Blakemoorflat, Shropshire.

FIG. 3. Paratype, BB 37123. Internal mould of a brachial valve, $\times 5.2$.

Mytton Flags, New Perkin's Level, Shropshire.

FIG. 5. Paratype, BB 37121a. Internal mould of a brachial valve, $\times 6$.

Pseudolingula spatula sp. nov. (p. 36)

Weston Beds, near Lyde, Shropshire.

FIG. 6. Paratype, BB 37126. Internal mould of a pedicle valve, $\times 2.9$.

FIGS. 7, 10. Paratype, BB 37128a, b. Latex cast of the exterior and the internal mould of a brachial valve, $\times 3$, $\times 3.2$.

FIG. 9. Paratype, BB 37125a. Internal mould of a brachial valve, $\times 3$.

Weston Beds, Cwm Dingle, Shropshire.

FIG. 8. Holotype, BB 37124a. Internal mould of a brachial valve, $\times 3$.

Rorrington Beds, Deadman's Dingle, Shropshire.

FIG. 11. BB 37130a. Internal mould of a pedicle valve, $\times 5.5$.

Meadowtown Beds, Minicop Farm, Shropshire.

FIGS. 12, 13. BB 37129. Fragments of the external lateral area and the interior of a pedicle valve, $\times 6$, $\times 6.4$.

Mytton Flags, River Camlad, Shropshire.

FIG. 14. BB 35583. Exfoliated pedicle valve, $\times 3$.

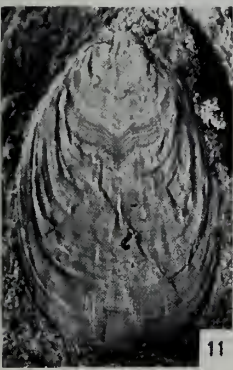
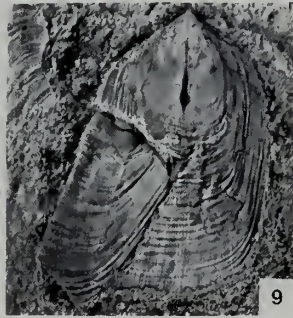
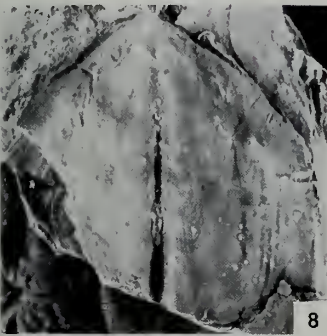
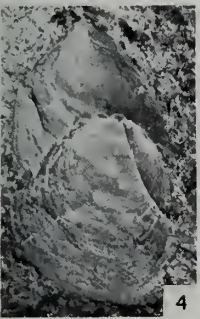
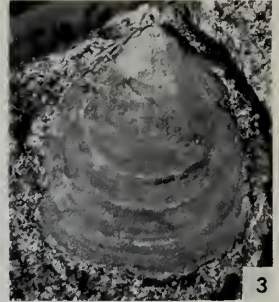
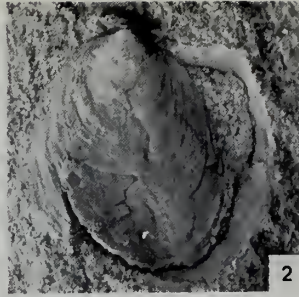


PLATE 5

Pseudolingula spatula sp. nov. (p. 36)

Weston Beds, near Lyde, Shropshire.

FIG. 1. Paratype, BB 37128b. Detail of the latex cast of the external mould of a brachial valve, $\times 21$.

Monobolina plumbea (Salter) (p. 38)

Mytton Flags, Old Perkin's Level, Shropshire.

FIG. 2. BB 35467. Latex cast of the interior of a pedicle valve, $\times 3.4$.

Mytton Flags, near Snailbeach Coppice, Shropshire.

FIGS. 3, 10. BB 35470a, b. Latex cast of the exterior and the internal mould of a brachial valve, $\times 5.4$, $\times 3.6$.

Mytton Flags, New Perkin's Level, Shropshire.

FIGS. 4, 7. BB 35468. Latex cast, with detail, of the exterior of a pedicle valve, $\times 6$, $\times 12$.

Mytton Flags, Perkin's Beach, Shropshire.

FIGS. 5, 6. BB 35473a. Latex cast of the interior and the internal mould of a pedicle valve, $\times 2.6$.

Mytton Flags, near St Luke's Church, Shropshire.

FIG. 8. BB 35472. Internal mould of a pedicle valve, $\times 2.4$.

Mytton Flags, Mytton Batch, Shropshire.

FIG. 9. BB 35469a. Internal mould of a brachial valve, $\times 2.8$.

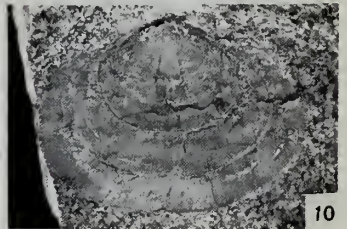
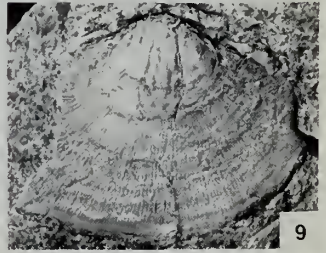
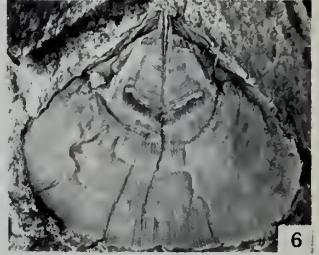
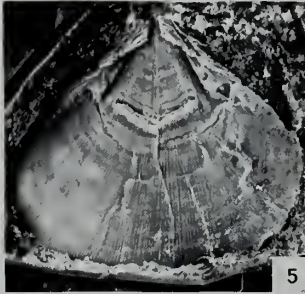
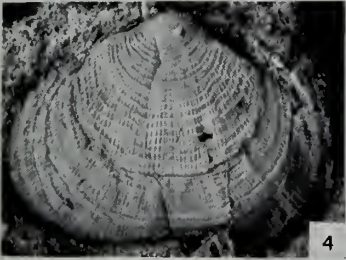
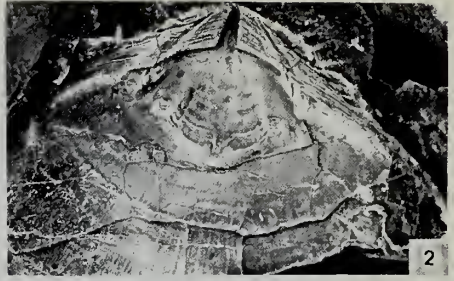
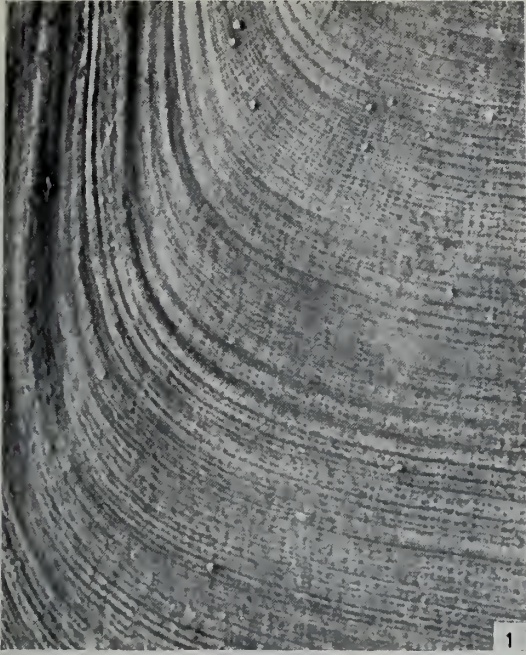


PLATE 6

Monobolina plumbea (Salter) (p. 38)

Mytton Flags, near Blakemoorflat, Shropshire.

FIG. 1. BB 35471. Latex cast of the internal mould of a pedicle valve, $\times 2.6$.

Paterula cf. *bohemica* Barrande (p. 40)

Hope Shales, Hope Dingle, Shropshire.

FIGS. 2, 3. BB 35588a, b. Latex cast of the exterior and the internal mould of a pedicle valve, $\times 11$.

FIGS. 5, 4. BB 35589a, b. Latex cast of the exterior and the internal mould of a brachial valve, $\times 11.9$.

Meadowtown Beds, Minicop Farm, Shropshire.

FIG. 6. BB 35590. Exterior of a pedicle valve, $\times 6$.

FIG. 7. BB 35591. Exterior of a brachial valve, $\times 11.1$.

FIG. 8. BB 35592. Exterior of a pedicle valve, $\times 11.9$.

FIG. 9. BB 35593. Exterior of a pedicle valve, $\times 11.9$.

FIG. 10. BB 35594. Exterior of a brachial valve, $\times 12.1$.

FIG. 11. BB 35595. Exterior of a brachial valve, $\times 10$.

Paterula cf. *perfecta* Cooper (p. 41)

Spy Wood Grit, Spy Wood Dingle, Shropshire.

FIG. 12. BB 35597. Exterior of a brachial valve, $\times 11$.

FIG. 13. BB 35596. Exterior of a pedicle valve, $\times 11.5$.

Apsotreta sp. (p. 42)

Mytton Flags, near Wood House, Shropshire.

FIGS. 14, 15. BB 35565a. Ventral and lateral views of the internal mould of a pedicle valve, $\times 7$, $\times 5$.

Conotreta stapeleyensis sp. nov. (p. 43)

Stapeley Shales, Leigh Hall, Shropshire.

FIG. 16. Holotype, BB 35566. Internal mould of a pedicle valve, $\times 7$.

FIG. 17. Paratype, BB 35568. Internal mould of a brachial valve, $\times 5.7$.

FIGS. 18, 19. Paratype, BB 35569. Latex cast of the interior and the internal mould of a brachial valve, $\times 7$, $\times 6$.

FIG. 20. Paratype, BB 35570. Internal mould of a brachial valve with adherent shell posteriorly, $\times 6$.

FIG. 21. Paratype, BB 35571b. Latex cast of the exterior of a pedicle valve, $\times 5.7$.

Schizocrania salopiensis sp. nov. (p. 44)

Rorrington Beds, near Desert, Shropshire.

FIG. 22. Paratype, BB 35361. Exterior of a brachial valve, $\times 7.1$.

FIG. 23. Paratype, BB 35362a. Internal mould of a brachial valve, $\times 4$.

Spy Wood Grit, near Rorrington, Shropshire.

FIG. 24. Paratype, BB 35359. Exterior of a brachial valve, $\times 3.5$.

FIG. 25. Holotype, BB 35358a. Internal mould of a brachial valve, $\times 2.2$.

Betton Beds, near Little Weston, Shropshire.

FIG. 26. Paratype, BB 35404a. Internal mould of a brachial valve, $\times 7$.

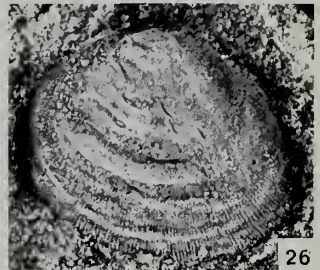
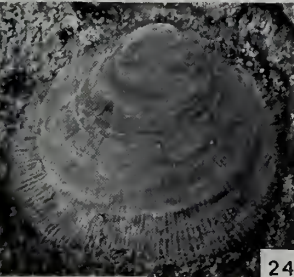
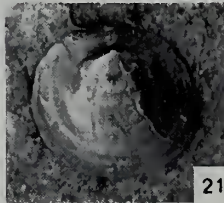
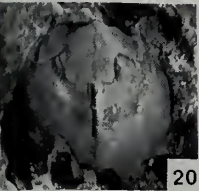
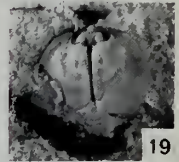
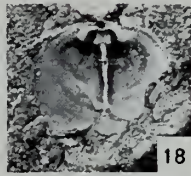
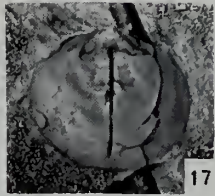
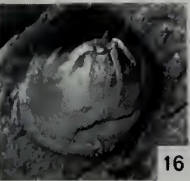
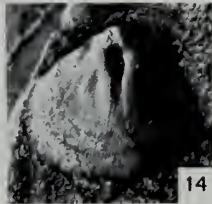
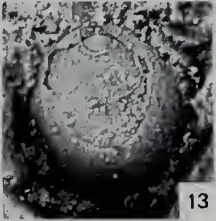
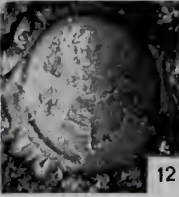
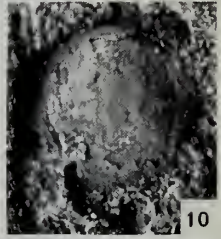
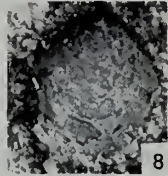
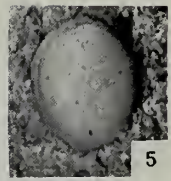
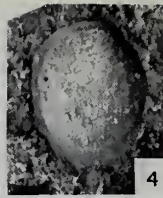
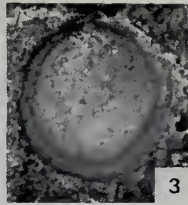
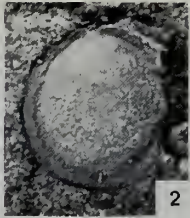
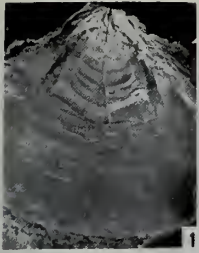


PLATE 7

Orbiculoidea sp. (p. 47)

Stapeley Shales, Shropshire (unlocated exposure).

FIG. 1. BB 35576. Latex cast of the exterior of a brachial valve, $\times 5$.

Schizotreta transversa sp. nov. (p. 47)

Meadowtown Beds, near Meadowtown Quarry, Shropshire.

FIG. 2. Paratype, BB 35578. Exfoliated pedicle valve, $\times 6.2$.

FIG. 7. Holotype, BB 35577. Exfoliated pedicle valve, $\times 6.7$.

Meadowtown Beds, Middleton, Shropshire.

FIG. 3. Paratype, BB 35579. Exfoliated brachial valve, $\times 7.1$.

Schizotreta sp. (p. 48)

Mytton Flags, New Perkin's Level, Shropshire.

FIG. 4. BB 35580. Latex cast of the exterior of a pedicle valve, $\times 8$.

Petrocrania dubia sp. nov. (p. 48)

Whittery Shales, near Hockleton Bridge, Shropshire.

FIGS. 8, 6, 5. Holotype, BB 35405a, b. Latex casts of the exterior and interior and the internal mould of a brachial valve, $\times 2.6$, $\times 3.5$, $\times 3$.

Hesperonomia sp. (p. 49)

Mytton Flags, Woodside House, Shropshire.

FIGS. 12, 9. BB 35334a, b. Latex casts of the external and internal moulds of a brachial valve, $\times 8.3$, $\times 5$.

Orthis cf. *callactis* Dalman (p. 50)

Mytton Flags, Crowsnest Dingle, Shropshire.

FIGS. 10, 11. BB 35498a, b. Latex cast of the exterior and the internal mould of a pedicle valve, $\times 3.6$.

Mytton Flags, near St Luke's Church, Shropshire.

FIG. 13. BB 35500. Latex cast of the exterior of a brachial valve, $\times 8.4$.

FIGS. 15, 14. BB 35497. Latex casts showing dorsal and ventral views of conjoined valves, $\times 3.4$.

FIG. 16. BB 35499. View of a fragment of the internal mould of a brachial valve and the external mould of the complementary pedicle valve, $\times 12.5$.

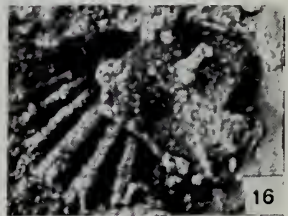
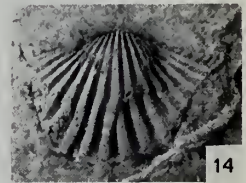
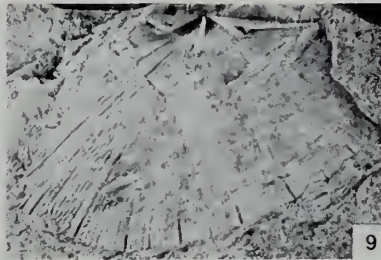
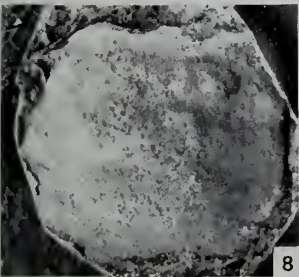
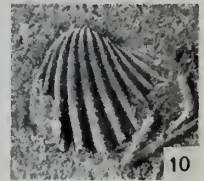
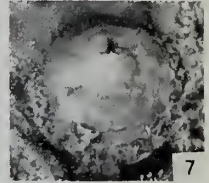
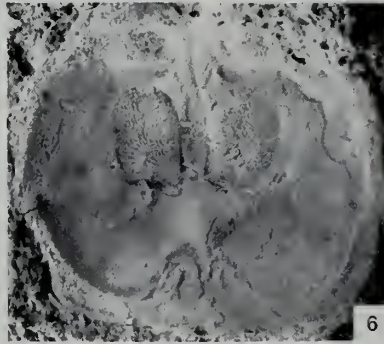
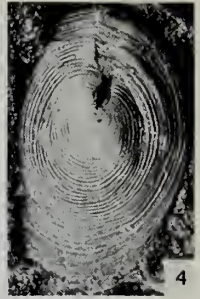
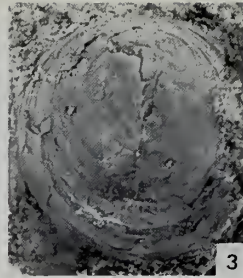
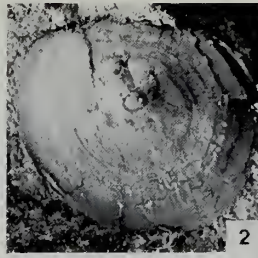
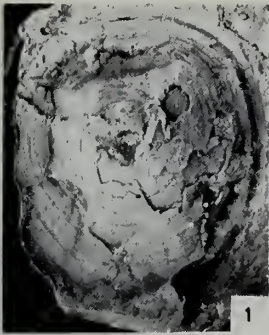


PLATE 8

Orthis sp. (p. 51)

Stapeley Volcanic Group, Leigh, Shropshire.

FIG. 1. BB 35425. Latex cast of the interior of a brachial valve, $\times 6.5$.

Lenorthis cf. *proava* (Salter) (p. 52)

Mytton Flags, Snailbeach, Shropshire.

FIGS. 3, 2. BB 35501a, b. Latex cast of the exterior and the internal mould of a pedicle valve, $\times 6.6$, $\times 3.4$.

FIGS. 5, 4. BB 35502a, b. Latex cast of the exterior and the internal mould of a pedicle valve, $\times 3.5$.

Mytton Flags, Perkin's Beach, Shropshire.

FIGS. 6, 9. BB 35504a. Latex cast and mould of the interior of a brachial valve, $\times 3.7$.

FIGS. 7, 8. BB 35503a, b. Latex cast of the exterior and interior of a brachial valve, $\times 3.5$.

Orthambonites exopunctata sp. nov. (p. 53)

Whittery Shales, near Hockleton Bridge, Shropshire.

FIGS. 10, 11. Holotype, BB 35371. General and detailed views of the exterior of a brachial valve, $\times 3.3$, $\times 10$.

FIG. 12. Paratype, BB 35372. Exterior of a brachial valve, $\times 3.2$.

FIGS. 13, 16. Paratype, BB 35376a, b. Interior and internal mould of pedicle valve, $\times 3.1$, $\times 3.9$.

FIG. 14. Paratype, BB 35373. Latex cast of the interior of a brachial valve, $\times 3.5$.

Whittery Shales, Whittery Quarry, Shropshire.

FIG. 15. Paratype, BB 35375. Internal mould of a pedicle valve, $\times 4.2$.

Whittery Shales, River Camlad, Shropshire.

FIG. 17. Paratype, BB 35374a. Latex cast of the interior of a brachial valve, $\times 4.7$.

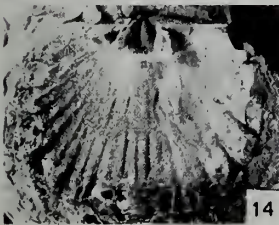
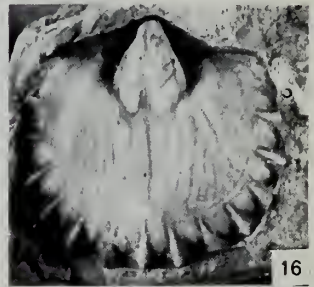
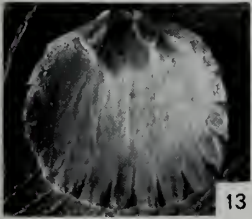
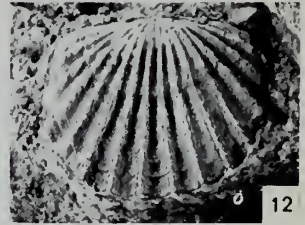
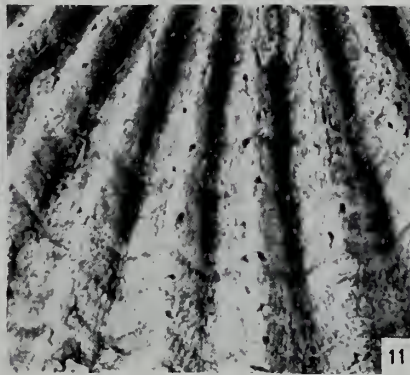
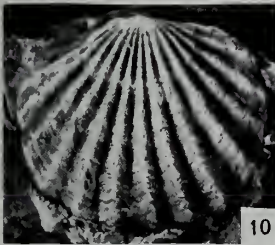
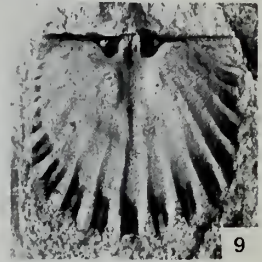
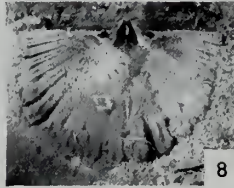
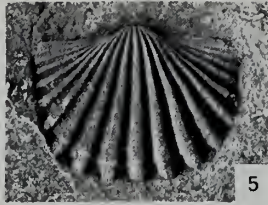
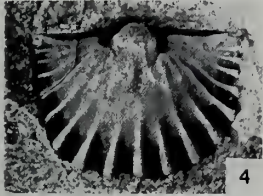
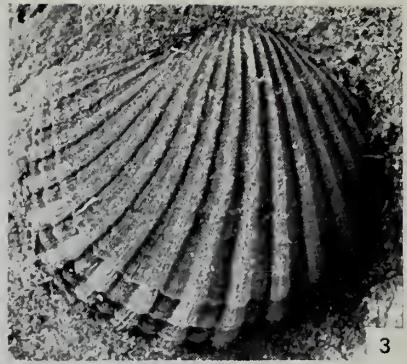
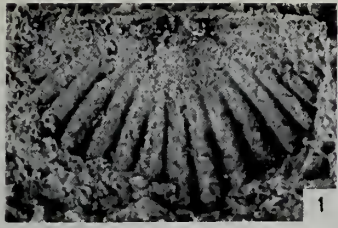


PLATE 9

Nicolella cf. *actoniae* (J. de C. Sowerby) (p. 57)

Whittery Shales, Whittery Quarry, Shropshire.

FIGS. 1, 4. BB 35327a, b. Latex casts of the exterior and interior of a brachial valve, $\times 6$.

Whittery Shales, near Hockleton Bridge, Shropshire.

FIG. 2. BB 35330. Latex cast of the interior of a pedicle valve, $\times 3$.

Whittery Shales, River Camlad, Shropshire.

FIG. 3. BB 35328a. Latex cast of the interior of a brachial valve, $\times 3.2$.

Whittery Shales, near Marrington Farm, Shropshire.

FIG. 5. BB 35331. Internal mould of a pedicle valve, $\times 2.8$.

FIG. 6. BB 35329. Latex cast of the exterior of a brachial valve, $\times 3.2$.

Whittardia paradoxica gen. et sp. nov. (p. 62)

Whittery Shales, Whittery Quarry, Shropshire.

FIGS. 7, 8. Paratype, BB 35385. Latex cast and mould of the interior of a brachial valve, $\times 3.6$, $\times 4.2$.

FIGS. 9, 13. Holotype, BB 35381b. Latex cast, with detail, of the exterior of a brachial valve, $\times 5.2$, $\times 13$.

FIG. 10. Paratype, BB 35403. Internal mould of a pedicle valve, $\times 5$.

FIGS. 12, 11. Paratype, BB 35383b. Latex cast, with detail, of the exterior of a pedicle valve, $\times 5$, $\times 12.5$.

FIG. 14. Paratype, BB 35382a. Internal mould of a pedicle valve, $\times 2.6$.

FIG. 15. Paratype, BB 35402a. Latex cast of the interior of a brachial valve, $\times 4.3$.

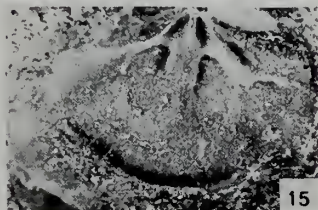
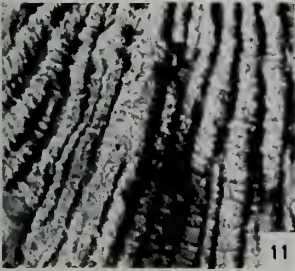
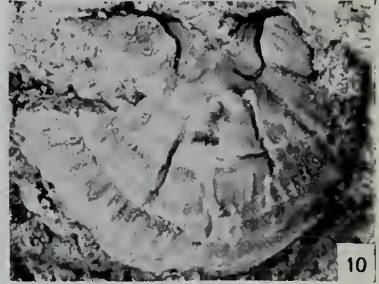
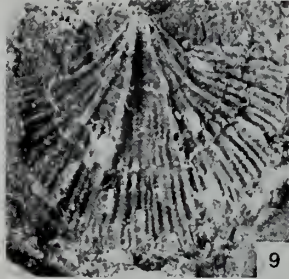
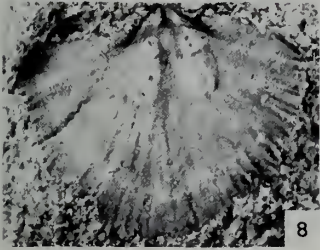
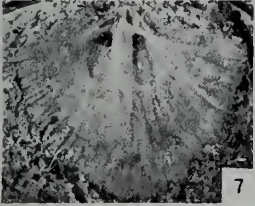
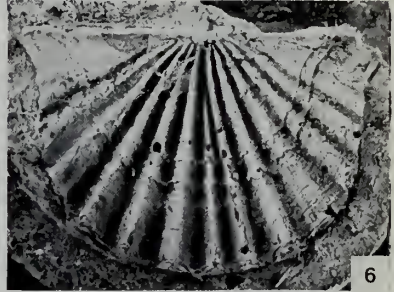


PLATE 10

Whittardia paradoxica gen. et sp. nov. (p. 62)

Whittery Shales, near Hockleton Bridge, Shropshire.

FIG. 1. Paratype, BB 35384b. Latex cast of the exterior of a brachial valve, $\times 4.8$.

Whittery Shales, Whittery Quarry, Shropshire.

FIG. 2. Paratype, BB 35383a. Internal mould of a pedicle valve, $\times 5.1$.

FIG. 4. Paratype, BB 35402b. Latex cast of the exterior of a brachial valve, $\times 5.7$.

Dolerorthis cf. *tenuicostata* Williams (p. 63)

Whittery Shales, Whittery Quarry, Shropshire.

FIGS. 3, 5. BB 35460a, b. Latex cast of the exterior and the internal mould of a pedicle valve, $\times 6.1$, $\times 3.6$.

FIGS. 7, 10, 13. BB 35459a, b. Latex casts of the exterior and the interior and the internal mould of a brachial valve, $\times 3.3$, $\times 3.6$, $\times 3.6$.

Glyptorthis viriosa sp. nov. (p. 64)

Spy Wood Grit, near Rorrington, Shropshire.

FIGS. 6, 14. Holotype, BB 35505a, b. Latex casts of the exterior and interior of a brachial valve, $\times 5$.

FIG. 8. Paratype, BB 35509. Internal mould of a pedicle valve, $\times 4.8$.

FIG. 9. Paratype, BB 35506a. Internal mould of a pedicle valve, $\times 5.3$.

FIG. 11. Paratype, BB 35508a. Latex cast of the interior of a brachial valve, $\times 5$.

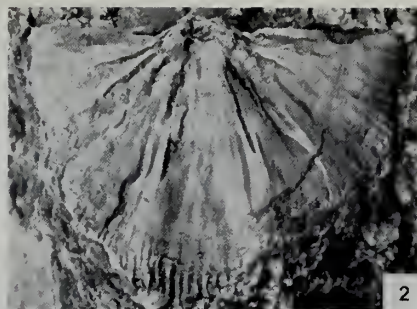
FIG. 12. Paratype, BB 35507. Internal mould of a pedicle valve, $\times 5$.

Meadowtown Beds, Minicop Farm, Shropshire.

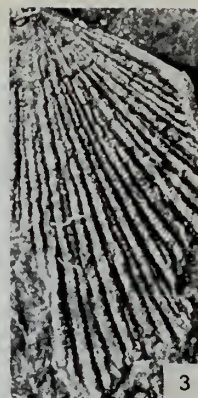
FIG. 15. BB 35520b. Latex cast of the exterior of a brachial valve, $\times 7.5$.



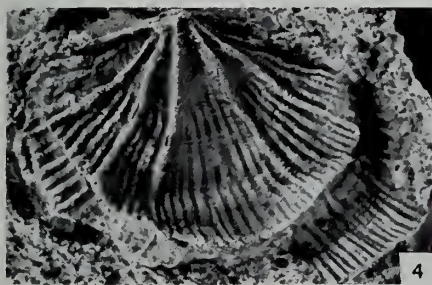
1



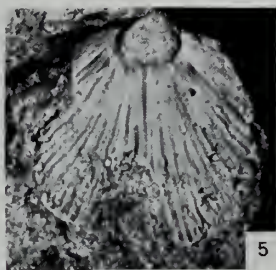
2



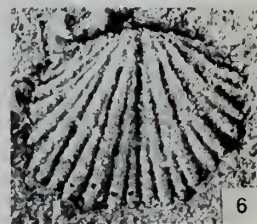
3



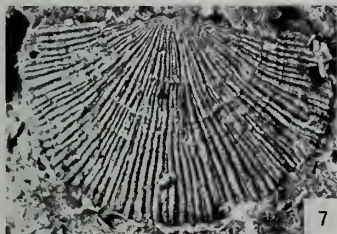
4



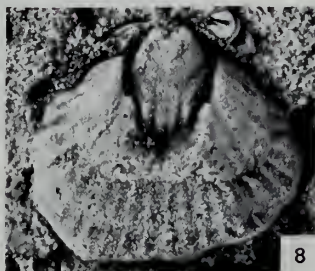
5



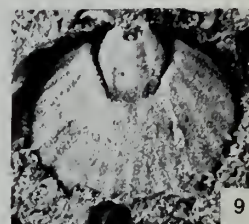
6



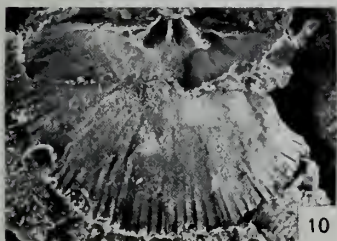
7



8



9



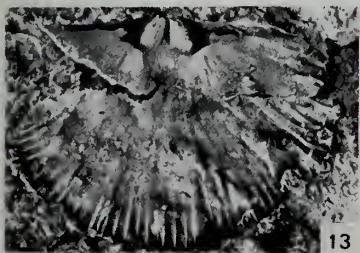
10



11



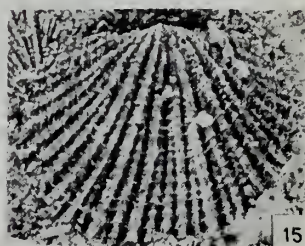
12



13



14



15

PLATE 11

Glyptorthis viriosa sp. nov. (p. 64)

Meadowtown Beds, Quinton's Quarry, Shropshire.

FIGS. 1, 2. BB 35521a, b. Latex cast of the exterior and the internal mould of a pedicle valve, $\times 6.8$, $\times 5.1$.

Meadowtown Beds, Minicop Farm, Shropshire.

FIG. 4. BB 35520a. Internal mould of a brachial valve, $\times 5.5$.

Diparelasma sp. (p. 71)

Mytton Flags, near Mytton's Beach, Shropshire.

FIG. 3. BB 35335a, b. Latex casts of the interior of a brachial valve and the exterior of the complementary pedicle valve, $\times 8$.

Mytton Flags, near Blakemoorflat, Shropshire.

FIGS. 7, 8. BB 35336a, b. Latex casts of the exterior and interior of a brachial valve, $\times 5$.

Astraborthis uniplicata gen. et sp. nov. (p. 70)

Mytton Flags, near Snailbeach Reservoir, Shropshire.

FIGS. 6, 5, 11. Paratype, BB 35325a, b. Latex casts of the exterior and interior and the internal mould of a brachial valve, $\times 4.7$, $\times 4$, $\times 4$.

FIGS. 14, 9. Holotype, BB 35324a, b. Latex cast of part of the exterior and the internal mould of a pedicle valve, $\times 4$, $\times 2.8$.

Plectorthis sp. (p. 73)

Aldress Shales, Ox Wood Dingle, Shropshire.

FIGS. 15, 12. BB 35466a. Latex cast and mould of the interior of a pedicle valve, $\times 2.7$.

Plectorthis whitteryensis sp. nov. (p. 71)

Whittery Shales, River Camlad, Shropshire.

FIGS. 13, 10. Holotype, BB 35462a, b. Latex cast of the exterior and the internal mould of a pedicle valve, $\times 3.4$.

FIG. 16. Paratype, BB 37158a. Internal mould of a pedicle valve, $\times 3.5$.

FIG. 17. Paratype, BB 35463a. Internal mould of a brachial valve, $\times 3.5$.

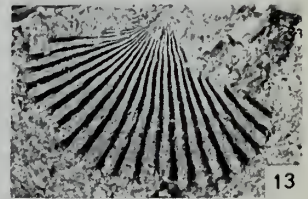
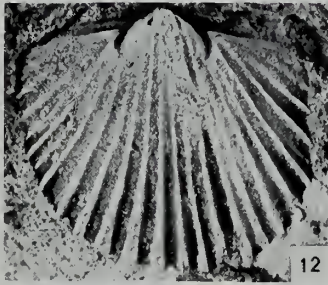
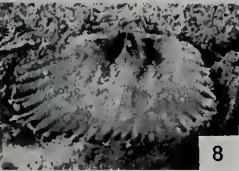
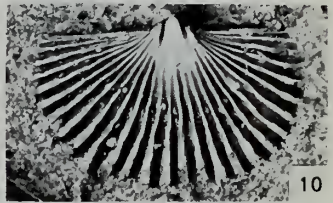
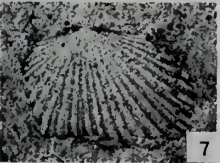
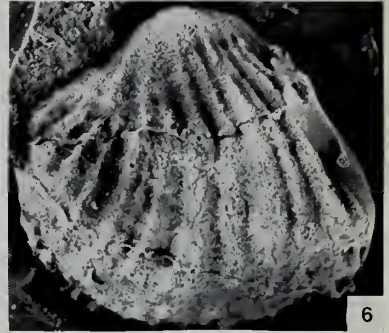
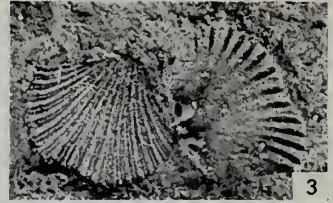
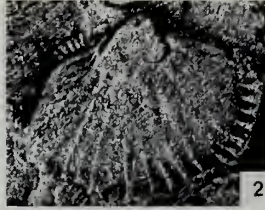


PLATE 12

Plectorthis whitteryensis sp. nov. (p. 71)

Whittery Shales, River Camlad, Shropshire.

FIG. 1. Paratype, BB 35464a. Latex cast of the interior of a brachial valve, $\times 3.5$.

Desmorthis ? sp. nov. (p. 73)

Stapeley Volcanic Group, Perkin's Beach, Shropshire.

FIG. 2. BB 35339a. Internal mould of pedicle valve, $\times 5$.

FIG. 3. BB 35338a. Internal mould of pedicle valve, $\times 6.3$.

Mytton Flags, near Blakemoorflat, Shropshire.

FIGS. 8, 4. BB 35337a, b. Latex casts of the exterior and interior of a brachial valve, $\times 4$, $\times 3$.

Gelidorthis cf. *partita* (Barrande) (p. 74)

Rorrington Beds, Spy Wood Brook, Shropshire.

FIG. 5. BB 35419a. Internal mould of a brachial valve, $\times 7$.

FIG. 6. BB 35418a. Internal mould of a pedicle valve, $\times 5$.

FIG. 7. BB 37159a. Internal mould of a pedicle valve, $\times 5$.

Tazzarinia elongata sp. nov. (p. 75)

Meadowtown Beds, near Waitchley, Shropshire.

FIGS. 9, 11, 10. Holotype, BB 35332a, b. Latex casts of the exterior and interior and the internal mould of a brachial valve, $\times 5.5$, $\times 6.2$, $\times 5$.

FIGS. 12, 15. Paratype, BB 35333a, b. Latex cast of the exterior and the internal mould of a pedicle valve, $\times 6.1$.

Platystrophia caelata sp. nov. (p. 76)

Whittery Shales, River Camlad, Shropshire.

FIGS. 16, 13. Paratype, BB 35495a, b. Latex cast of the exterior and the internal mould of a pedicle valve, $\times 4$, $\times 2.5$.

FIG. 17. Paratype, BB 35494a. Internal mould of a pedicle valve, $\times 2.7$.

Whittery Shales, Whittery Quarry, Shropshire.

FIGS. 19, 14, 18. Holotype, BB 35493a, b. Latex cast and detail of the mould of the exterior and the internal mould of a brachial valve, $\times 2.6$, $\times 14$, $\times 2.6$.

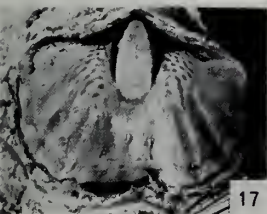
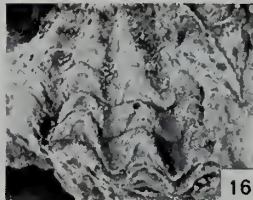
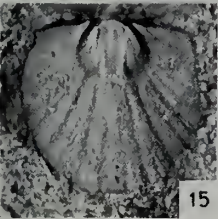
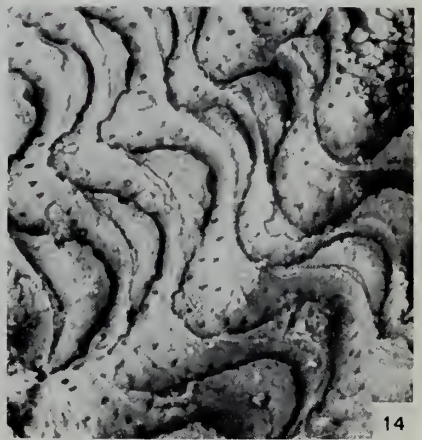
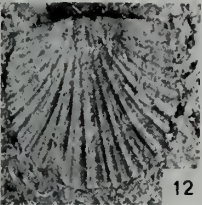
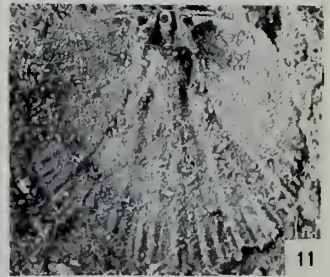
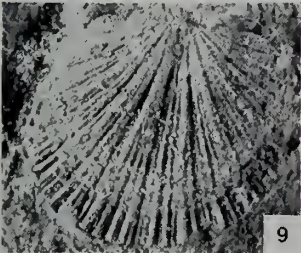
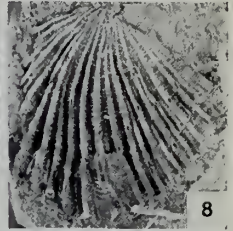
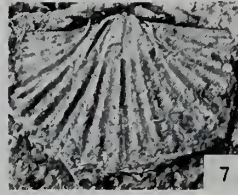
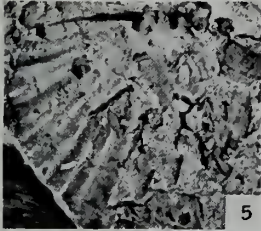
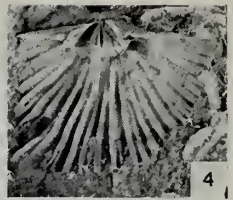
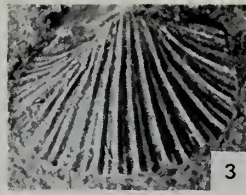
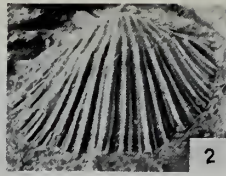


PLATE 13

Platystrophia cf. *major* Williams (p. 78)

Address Shales, Ox Wood Dingle, Shropshire.

FIG. 1. BB 35586a. Internal mould of a brachial valve, $\times 7$.

Spy Wood Grit, near Rorrington, Shropshire.

FIGS. 4, 2. BB 35587a, b. Latex cast of the exterior and the internal mould of a pedicle valve, $\times 6.2$.

Mcewanella sp. (p. 78)

Whittery Shales, near Hockleton Bridge, Shropshire.

FIG. 3. BB 35417. Internal mould of a pedicle valve, $\times 2.1$.

FIG. 5. BB 35416. Exterior of a pedicle valve, $\times 2.4$.

Salacorthis costellata gen. et sp. nov. (p. 80)

Spy Wood Grit, near Rorrington, Shropshire.

FIGS. 7, 11, 6, 10. Holotype, BB 37153a, b. Latex casts and moulds of the exterior and interior of a brachial valve, $\times 7.6$, $\times 4.9$, $\times 7.6$, $\times 7.6$.

FIG. 8. Paratype, BB 37154. Internal mould of a pedicle valve, $\times 3.1$.

FIG. 12. Paratype, BB 37155. Latex cast of the exterior of a brachial valve, $\times 3.6$.

FIG. 13. Paratype, BB 37157. Latex cast of the exterior of a brachial valve, $\times 5.1$.

Spy Wood Grit, Spy Wood Brook, Shropshire.

FIG. 9. Paratype, BB 37156. Latex cast of the exterior of a brachial valve, $\times 6$.

Skenidioides cf. *costatus* Cooper (p. 82)

Spy Wood Grit, Spy Wood Brook, Shropshire.

FIG. 14. BB 35413. Latex cast of the exterior of a pedicle valve, $\times 12$.

Whittery Shales, River Camlad, Shropshire.

FIGS. 16, 15. BB 35409. Latex cast and mould of the interior of a brachial valve, $\times 5.7$, $\times 7$.

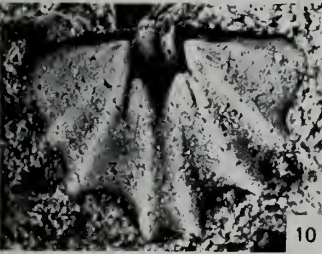
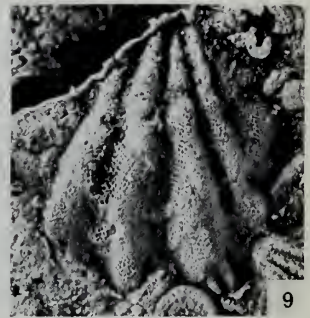
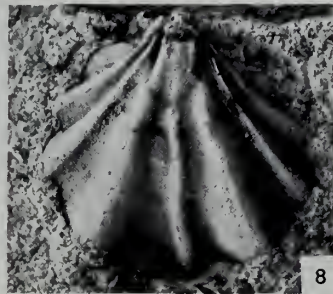
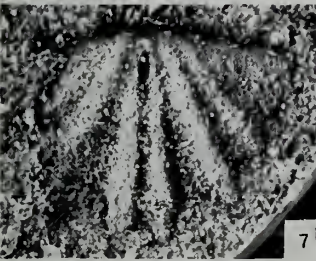
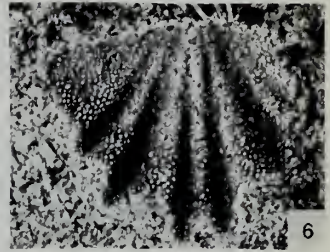
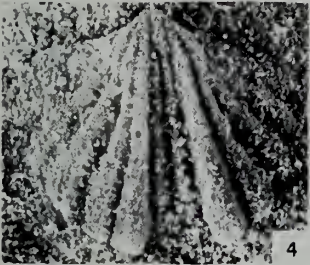
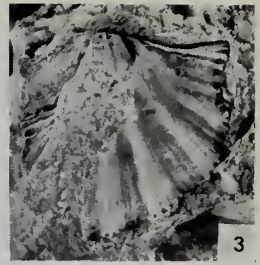
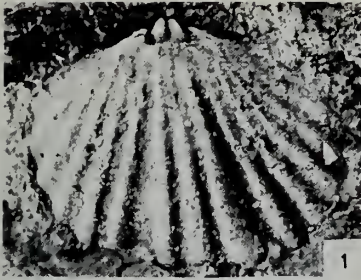


PLATE 14

Skenidioides cf. *costatus* Cooper (p. 82)

Whittry Shales, Hockleton Bridge, Shropshire.

- FIG. 1. BB 35410. Internal mould of a pedicle valve, $\times 7.2$.
Spy Wood Grit, Spy Wood Brook, Shropshire.
FIG. 2. BB 35411. Internal mould of a pedicle valve, $\times 13.3$.
FIG. 3. BB 35412. Internal mould of a pedicle valve, $\times 12.5$.

Protoskenidioides revelata gen. et sp. nov. (p. 85)

Mytton Flags, near Gravels, Shropshire.

- FIG. 4. Paratype, BB 35395a. Internal mould of a pedicle valve, $\times 13.6$.
FIG. 9. Paratype, BB 35394b. Latex cast of the exterior of a brachial valve, $\times 10$.
FIG. 11. Paratype, BB 35397b. Latex cast of the exterior of a brachial valve, $\times 12.5$.
FIG. 12, 6. Paratype, BB 35400a. Latex cast and mould of the interior of a brachial valve,
 $\times 9$, $\times 14$.

Mytton Flags, near Shelve Church, Shropshire.

- FIG. 5. Holotype, BB 35387. Internal mould of a brachial valve, $\times 12.4$.
FIG. 7. Paratype, BB 35389. Internal mould of a pedicle valve, $\times 15$.
FIG. 8. Paratype, BB 35399a. Internal mould of a brachial valve, $\times 14$.
FIG. 10. Paratype, BB 35393. Internal mould of a brachial valve, $\times 14.5$.
FIG. 13. Paratype, BB 35398a. Internal mould of a brachial valve, $\times 10$.

Drabovia cf. *fascicostata* Havlíček (p. 87)

Spy Wood Grit, near Rorrington, Shropshire.

- FIG. 14. BB 35319b. Latex cast of the exterior of a pedicle valve, $\times 7.1$.
FIGS. 15, 18. BB 35316a, b. Latex casts of the exterior and interior of a brachial valve, $\times 8$.
FIG. 16. BB 35317a. Internal mould of a brachial valve, $\times 6.4$.
FIG. 19. BB 35318a. Internal mould of a pedicle valve, $\times 6.7$.

Nocturniella sp. (p. 88)

Mytton Flags, Snailbeach, Shropshire.

- FIGS. 17, 20. BB 35341. Latex cast and mould of the interior of a brachial valve, $\times 7$.

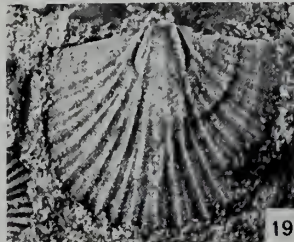
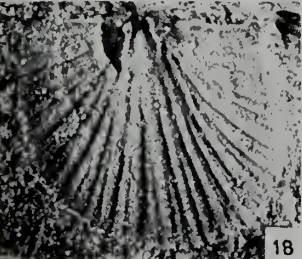
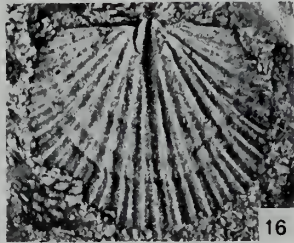
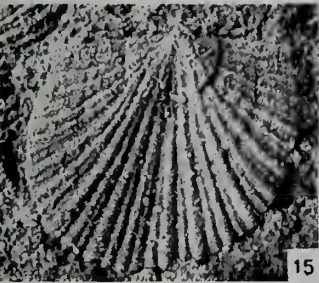
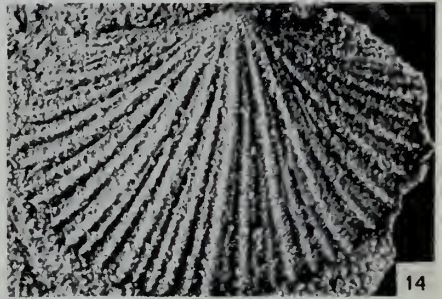
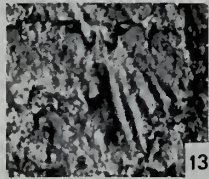
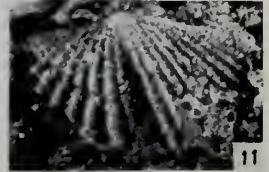
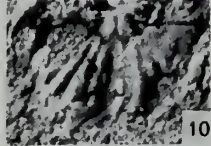
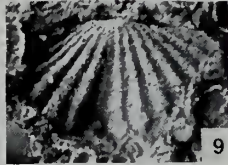
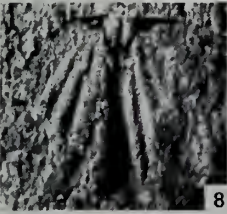
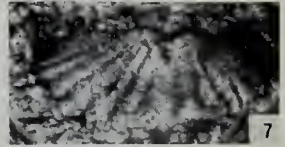
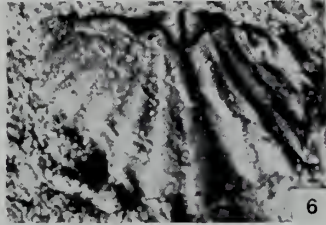
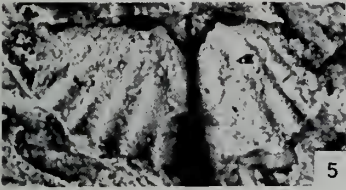
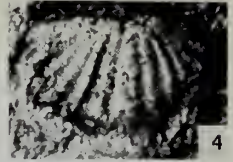
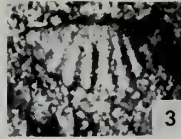


PLATE 15

Dalmanella parva Williams (p. 89)

Lower Llandeilo sandstones, near Ysgubor-wen Farm, Llandeilo, Carmarthenshire.

FIG. 1. BB 35436. Internal mould of a brachial valve, $\times 8$.

FIG. 2. BB 35437. Latex cast of the exterior of a brachial valve, $\times 6$.

FIGS. 3, 7. BB 35434. Latex cast and mould of the interior of a brachial valve, $\times 6.5$.

FIG. 4. BB 35435. Internal mould of a pedicle valve, $\times 6.9$.

Dalmanella salopiensis sp. nov. (p. 90)

Meadowtown Beds, near Minicop Farm, Shropshire.

FIGS. 8, 5. Holotype, BB 35446a, b. Latex cast of the exterior and the internal mould of a brachial valve, $\times 8$, $\times 6$.

FIG. 11. Paratype, BB 35448a. Internal mould of a brachial valve, $\times 6.3$.

Meadowtown Beds, Quinton's Quarry, Shropshire.

FIGS. 12, 6. Paratype, BB 35450a, b. Latex casts of the exterior and interior of a brachial valve, $\times 7.2$.

Meadowtown Beds, near Meadowtown Chapel, Shropshire.

FIGS. 10, 9. Paratype, BB 35447a, b. Latex cast of the exterior and the internal mould of a pedicle valve, $\times 6.9$, $\times 7.8$.

Dalmanella salopiensis gregaria sp. et subsp. nov. (p. 91)

Spy Wood Grit, Spy Wood Brook, Shropshire.

FIGS. 16, 13. Holotype, BB 35443a, b. Latex cast of the exterior and the internal mould of a brachial valve, $\times 6.4$, $\times 7.5$.

FIG. 14. Paratype, BB 35407a. Internal mould of a pedicle valve, $\times 7.3$.

FIG. 15. Paratype, BB 35444a. Internal mould of a pedicle valve, $\times 9$.

FIG. 20. Paratype, BB 35445a. Latex cast of the interior of a brachial valve, $\times 10$.

Dalmanella salopiensis transversa sp. et subsp. nov. (p. 92)

Aldress Shales, Ox Wood Dingle, Shropshire.

FIGS. 21, 19. Holotype, BB 35438a, b. Latex casts of the exterior and interior of a brachial valve, $\times 6.5$.

FIGS. 22, 23. Paratype, BB 35441a, b. Latex cast of the exterior and the internal mould of a pedicle valve, $\times 10$.

FIG. 24. Paratype, BB 35439a. Internal mould of a pedicle valve, $\times 6.9$.

FIGS. 18, 17. Paratype, 35440a, b. Latex cast of the exterior and the internal mould of a brachial valve, $\times 10$.

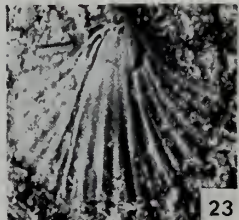
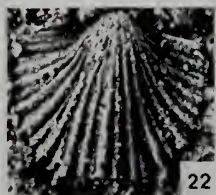
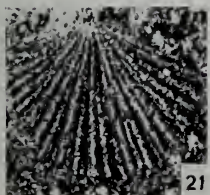
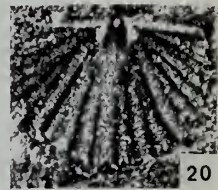
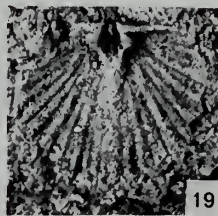
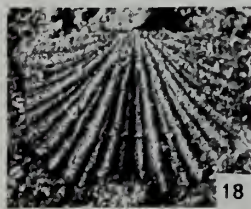
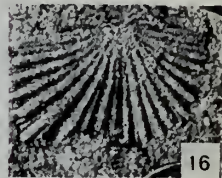
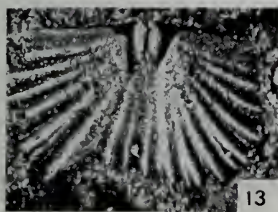
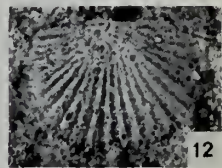
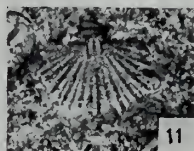
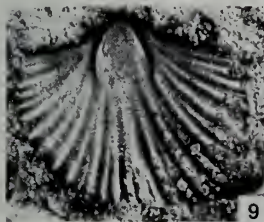
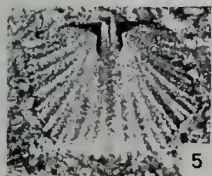
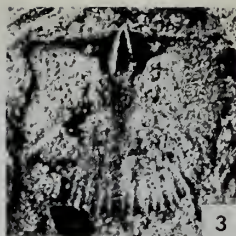
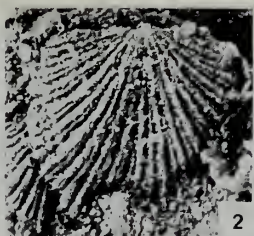
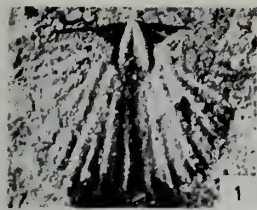


PLATE 16

Dalmanella salopiensis transversa sp. et subsp. nov. (p. 92)

Address Shales, Ox Wood Dingle, Shropshire.

FIG. 1. Paratype, BB 35442a. Internal mould of a pedicle valve, $\times 10$.

Dalmanella elementaria sp. nov. (p. 97)

Mytton Flags, near Shelve Church, Shropshire.

FIGS. 2, 3. Holotype, BB 35352a, b. Latex cast of the exterior and the internal mould of a brachial valve, $\times 7.8$.

FIG. 4. Paratype, BB 35357a. Internal mould of a brachial valve, $\times 8$.

FIG. 7. Paratype, BB 35355a. Internal mould of a brachial valve, $\times 8.3$.

FIG. 8. Paratype, BB 35356a. Internal mould of a brachial valve, $\times 8$.

Mytton Flags, near Wood House, Shropshire.

FIGS. 5, 6. Paratype, BB 35353a, b. Latex cast of the exterior and the internal mould of a pedicle valve, $\times 8$.

Onniella ostentata lepida subsp. nov. (p. 98)

Address Shales, Ox Wood Dingle, Shropshire.

FIG. 9. Paratype, BB 35457a. Internal mould of a brachial valve, $\times 5.7$.

FIGS. 10, 11. Holotype, BB 35456a, b. Latex cast of the exterior and the internal mould of a brachial valve, $\times 7$, $\times 5.6$.

FIG. 12. Paratype, BB 35458. Latex cast of the interior of a brachial valve, $\times 8$.

FIGS. 13, 14. Paratype, BB 35455a, b. Latex cast of the exterior and the internal mould of a pedicle valve, $\times 6.0$, $\times 5.8$.

Onniella sp. (p. 99)

Spy Wood Grit, Shropshire (unlocated exposure).

FIGS. 15, 18. BB 35572a, b. Latex casts of the exterior and interior of a brachial valve, $\times 6$.

Harknessella cf. *subplicata* Bancroft (p. 102)

Spy Wood Grit, near Rorrington, Shropshire.

FIG. 16. BB 35427. Internal mould of a brachial valve, $\times 6.7$.

Horderleyella cf. *plicata* Bancroft (p. 102)

Spy Wood Grit, near Rorrington, Shropshire.

FIG. 17. BB 35432. Internal mould of a brachial valve, $\times 6.6$.

FIGS. 19, 20. BB 35431a, b. Latex cast of the exterior and the internal mould of a pedicle valve, $\times 4$.

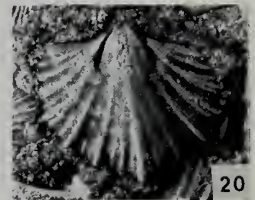
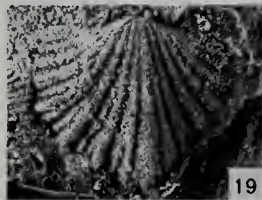
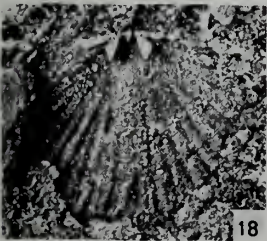
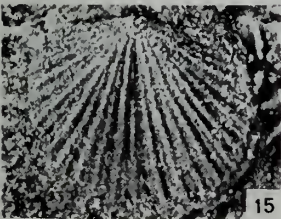
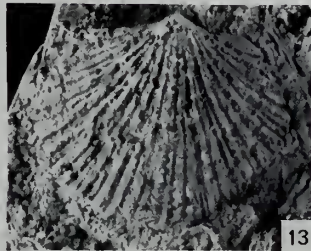
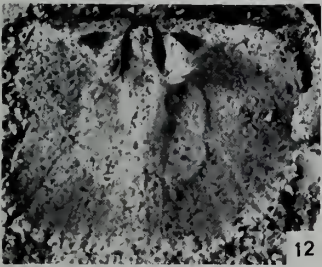
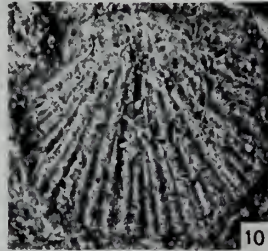
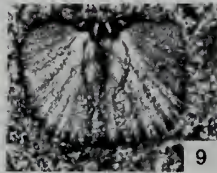
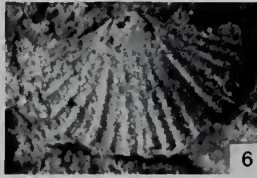
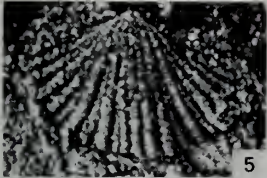
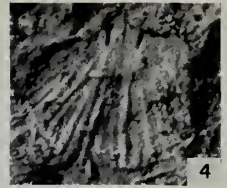
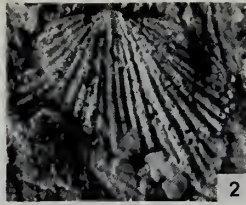
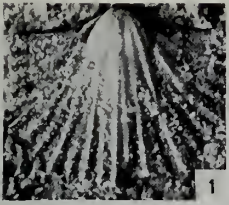


PLATE 17

Holderleyella cf. *plicata* Bancroft (p. 102)

Address Shales, Ox Wood Dingle, Shropshire.

FIG. 1. BB 35433. Internal mould of a brachial valve, $\times 4.5$.

Holderleyella sp. (p. 104)

Meadowtown Beds, near Meadowtown Chapel, Shropshire.

FIGS. 2, 3. BB 35420a, b. Internal mould and latex cast of the exterior of a pedicle valve, $\times 7.5$.

Reuschella holderleyensis carinata subsp. nov. (p. 104)

Whittery Shales, near Marrington Farm, Shropshire.

FIG. 4. Paratype, BB 35519a. Internal mould of a brachial valve, $\times 6$.

Whittery Shales, River Camlad, Shropshire.

FIG. 5. Holotype, BB 35513a. Internal mould of a pedicle valve, $\times 2.1$.

FIG. 6. Paratype, BB 35517a. Internal mould of a pedicle valve, $\times 1.9$.

FIG. 7. Paratype, BB 35515. Latex cast of the exterior of a pedicle valve, $\times 2.1$.

FIG. 8. Paratype, BB 35514a. Internal mould of a brachial valve, $\times 2.6$.

FIG. 9. Paratype, BB 35518a. Latex cast of the interior of a brachial valve, $\times 2$.

Heterorthis sp. (p. 106)

Spy Wood Grit, near Rorrington, Shropshire.

FIGS. 10, 14, 12. BB 35424a, b. Latex casts of the exterior and interior and the internal mould of a brachial valve, $\times 8$, $\times 6$, $\times 4.9$.

FIGS. 11, 13. BB 35423a, b. Latex cast of the exterior and the internal mould of a pedicle valve, $\times 6$.

Tissintia prototypa Williams (p. 108)

Lower Llanvirn ashy shales, near Llwyn Bedw Farm, Llandeilo, Carmarthenshire.

FIG. 15. BB 35310. Latex cast of the interior of a brachial valve, $\times 3.2$.

FIG. 16. BB 35305. Latex cast of the interior of a brachial valve, $\times 3.3$.

FIGS. 18, 17. BB 35309. Latex cast and internal mould of a brachial valve, $\times 2.3$.

FIG. 19. BB 35308. Latex cast of the exterior of a brachial valve, $\times 3.5$.

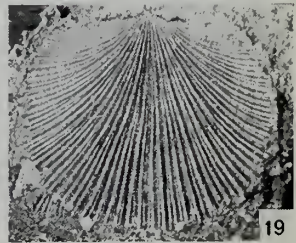
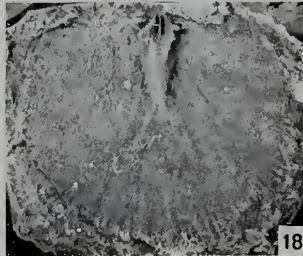
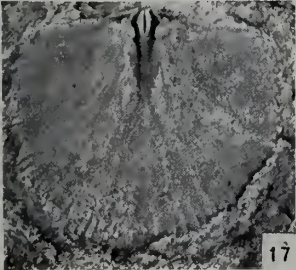
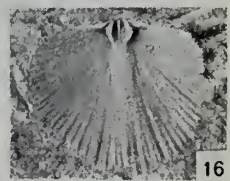
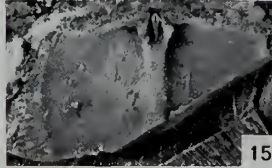
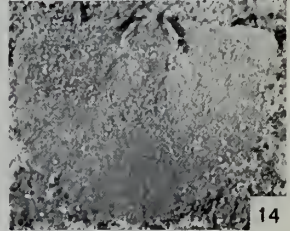
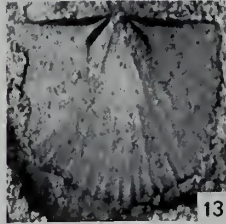
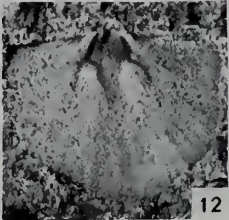
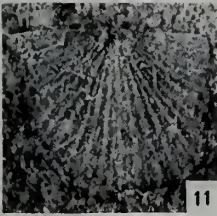
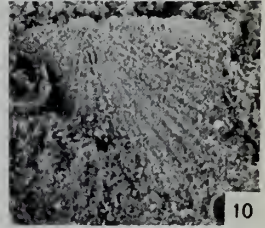
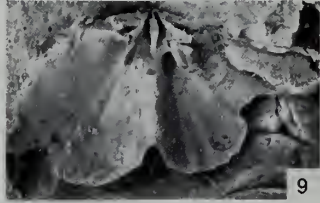
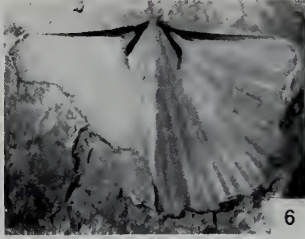
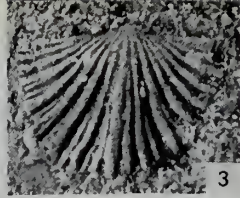
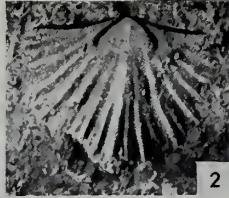
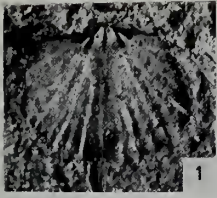


PLATE 18

Tissintia prototypa (Williams) (p. 108)

Lower Llanvirn ashy shales, near Llwyn Bedw Farm, Llandeilo, Carmarthenshire.

FIG. 1. BB 35306. Internal mould of a pedicle valve, $\times 3$.

FIG. 2. BB 35307. Latex cast of the exterior of a brachial valve, $\times 3.3$.

Weston Beds, near Lyde, Shropshire.

FIGS. 11, 3. BB 35311a, b. Latex cast of the exterior and the internal mould of a pedicle valve, $\times 1.9$, $\times 2.4$.

FIG. 6. BB 35315a. Latex cast of the interior of a brachial valve, $\times 2.5$.

FIGS. 8, 7. BB 35314a. Latex cast and internal mould of a brachial valve, $\times 2.2$.

Weston Beds, near Priestweston, Shropshire.

FIGS. 5, 4. BB 35312a. Latex cast and mould of the interior of a pedicle valve, $\times 2.6$.

Weston Beds, near Little Weston, Shropshire.

FIG. 9. BB 35313b. Latex cast of the exterior of a brachial valve, $\times 2$.

Tissintia immatura (Williams) (p. 109)

Meadowtown Beds, Quinton's Quarry, Shropshire.

FIG. 10. BB 35479. Internal mould of a pedicle valve, $\times 2.7$.

Meadowtown Beds, near Meadowtown, Shropshire.

FIG. 12. BB 35477a. Latex cast of the internal mould of a brachial valve, $\times 2$.

FIG. 15. BB 35476b. Latex cast of the exterior of a pedicle valve, $\times 3.8$.

Meadowtown Beds, Minicop Farm, Shropshire.

FIGS. 13, 14. BB 35474a, b. Latex cast of the exterior and the internal mould of a pedicle valve, $\times 2$, $\times 2.5$.

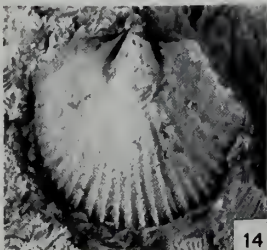
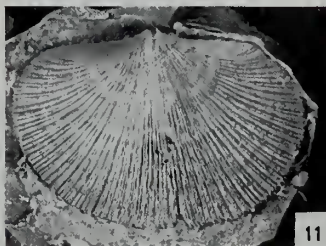
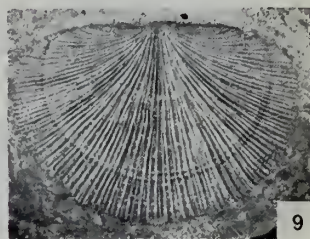
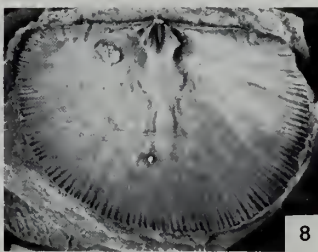
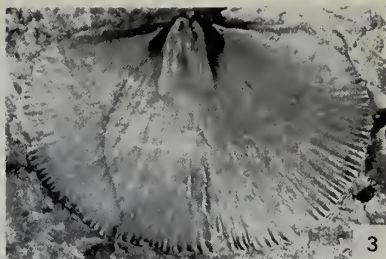
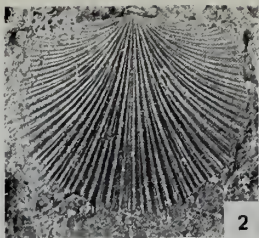
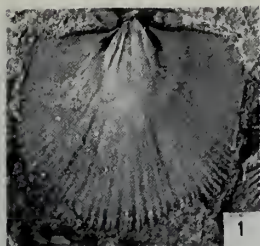


PLATE 19

Tissintia immatura (Williams) (p. 109)

Meadowtown Beds, Meadowtown Quarry, Shropshire.

FIGS. 1, 2, 5. BB 35478a, b. Latex casts of the exterior and interior and the internal mould of a brachial valve, $\times 3.8$, $\times 3.5$, $\times 2.5$.

Meadowtown Beds, Minicop Farm, Shropshire.

FIGS. 3, 4. BB 35475a, b. Latex cast of the exterior and the internal mould of a brachial valve, $\times 2.5$.

Salopia sp. (p. 114)

Whittery Shales, Whittery Quarry, Shropshire.

FIGS. 9, 6. BB 35428a, b. Latex cast of the exterior and the internal mould of a brachial valve, $\times 4.6$, $\times 3.5$.

FIG. 8. BB 35429a. Internal mould of pedicle valve, $\times 2.9$.

Whittery Shales, near Hockleton Bridge, Shropshire.

FIG. 7. BB 35430a. Internal mould of pedicle valve, $\times 3$.

Salopia cf. *salteri* (Davidson) (p. 114)

Spy Wood Grit, near Rorrington, Shropshire.

FIGS. 10, 11. BB 35426a. Latex cast and mould of the interior of a brachial valve, $\times 4.2$, $\times 5$.

Oslogonites ? sp. (p. 115)

Mytton Flags, near Wood House, Shropshire.

FIGS. 12, 13. BB 35326a, b. Latex cast of the exterior and the internal mould of a brachial valve, $\times 10$.

Kullervo sp. (p. 115)

Meadowtown Beds, near Meadowtown Chapel, Shropshire.

FIGS. 15, 14. BB 35340a, b. Latex cast of the exterior and the internal mould of a pedicle valve, $\times 8$, $\times 5.5$.

Triplesia sp. (p. 116)

Whittery Shales, near Hockleton Bridge, Shropshire.

FIG. 16. BB 35408. Internal mould of a pedicle valve, $\times 2.5$.

Bicuspinga subquadrata sp. nov. (p. 117)

Whittery Shales, Whittery Quarry, Shropshire.

FIG. 17. Paratype, BB 35481b. Latex cast of the exterior of a brachial valve, $\times 2.1$.

FIG. 19. Paratype, BB 35483. Internal mould of a brachial valve, $\times 1.9$.

Whittery Shales, River Camlad, Shropshire.

FIG. 18. Holotype, BB 35480a. Internal mould of a pedicle valve, $\times 1.6$.

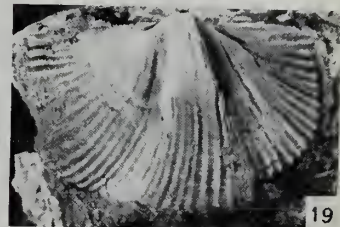
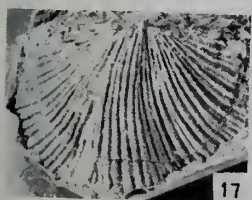
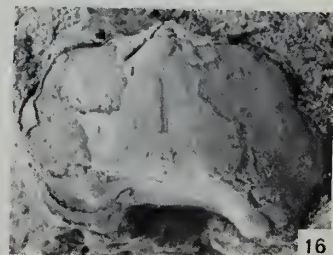
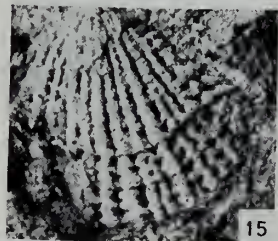
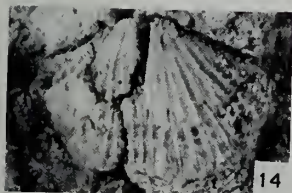
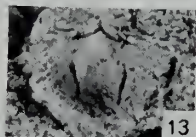
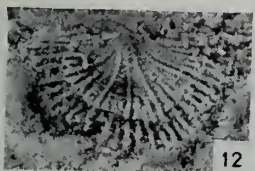
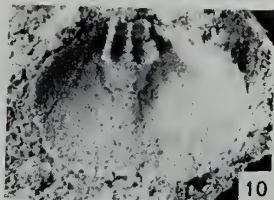
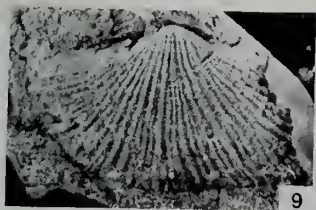
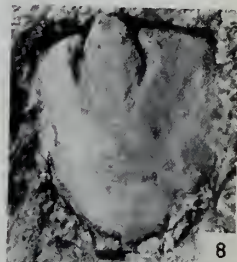
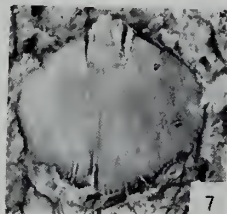
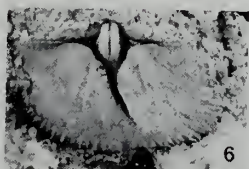
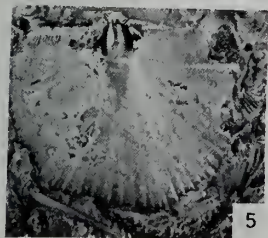
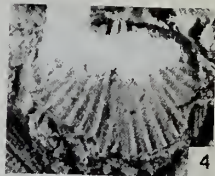
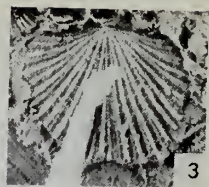


PLATE 20

Bicuspina subquadrata sp. nov. (p. 117)

Whittery Shales, Whittery Quarry, Shropshire.

FIGS. 1, 2. Paratype, BB 35482a, b. Latex cast of the exterior and the internal mould of a pedicle valve, $\times 2.8$.

Bicuspina modesta sp. nov. (p. 118)

Spy Wood Grit, near Rorrington, Shropshire.

FIGS. 3, 4. Paratype, BB 35512a, b. Latex cast of the exterior and the internal mould of a brachial valve, $\times 3.4$.

FIGS. 5, 6. Holotype, BB 35510a, b. Latex cast of the exterior and the internal mould of a pedicle valve, $\times 3.2$, $\times 3.5$.

FIGS. 7, 8. Paratype, BB 35511a, b. Latex cast of the exterior and the internal mould of a brachial valve, $\times 3.3$.

Oxoplecia cf. *nantensis* MacGregor (p. 125)

Meadowtown Beds, near Waitchley, Shropshire.

FIGS. 10, 9. BB 35320a, b. Latex cast of the exterior and the internal mould of a pedicle valve, $\times 3$.

FIG. 12. BB 35321. Internal mould of a brachial valve, $\times 4.5$.

FIG. 13. BB 35323. Latex cast of the interior of a brachial valve, $\times 5$.

Meadowtown Beds, near Little Weston, Shropshire.

FIG. 11. BB 35322a. Internal mould of a brachial valve, $\times 3.5$.

Caeroplecia plicata gen. et sp. nov. (p. 122)

Whittery Shales, Whittery Quarry, Shropshire.

FIGS. 15, 14. Paratype, BB 35349a, b. Latex cast of the exterior and the internal mould of a brachial valve, $\times 3$.

FIG. 16. Paratype, BB 35351b. Latex cast of the exterior of a brachial valve, $\times 3.2$.

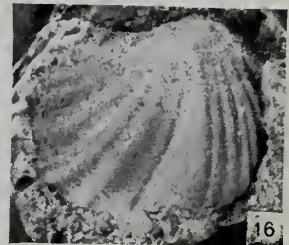
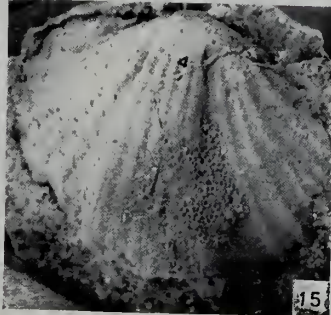
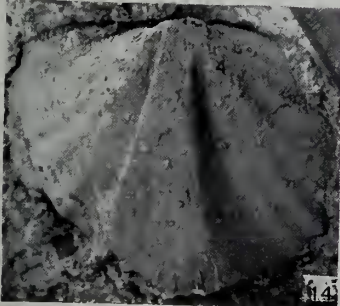
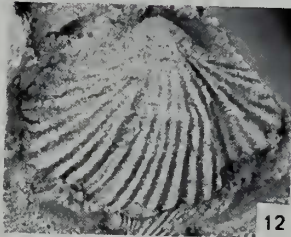
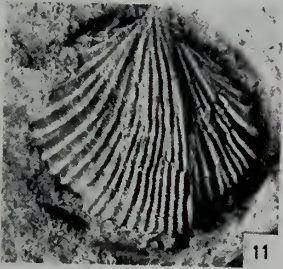
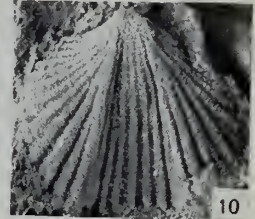
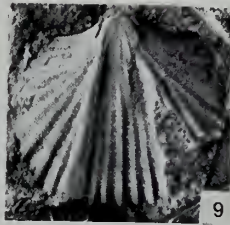
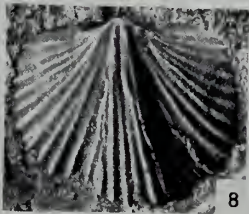
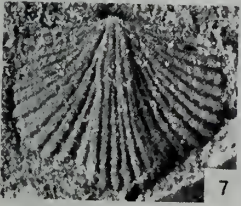
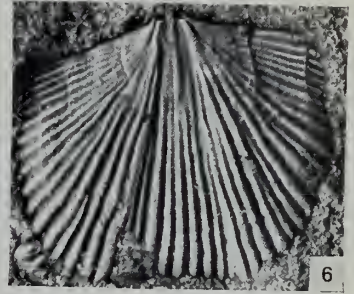
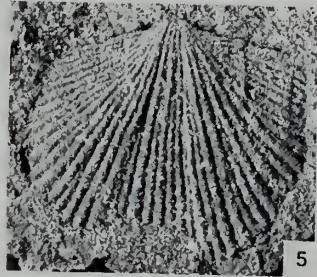
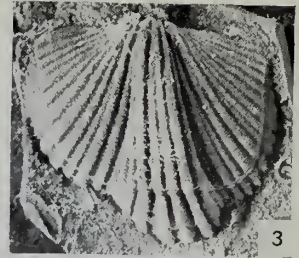
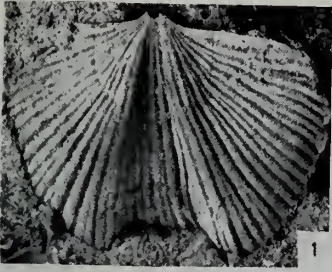


PLATE 21

Caeroplecia plicata gen. et sp. nov. (p. 122)

Whittery Shales, Whittery Quarry, Shropshire.

FIGS. 1, 2. Holotype, BB 35342b. Latex cast, with detail, of the exterior of a pedicle valve, $\times 4.6$, $\times 14$.

FIG. 4. Paratype, BB 35346a. Internal mould of a pedicle valve, $\times 3.4$.

FIGS. 5, 6. Paratype, BB 35348a, b. Latex casts of the exterior and interior of a brachial valve, $\times 2.6$, $\times 2.1$.

Whittery Shales, near Hockleton Bridge, Shropshire.

FIG. 3. Paratype, BB 35347a. Internal mould of a pedicle valve, $\times 3$.

Whittery Shales, River Camlad, Shropshire.

FIG. 5. Paratype, BB 35350a. Internal mould of a brachial valve, $\times 4.6$.

Palaeostrophomena sp. (p. 126)

Whittery Shales, Whittery Quarry, Shropshire.

FIGS. 7, 13. BB 35414a, b. Latex casts of the exterior of a pedicle and the complementary brachial valve, $\times 4$.

Whittery Shales, near Marrington Farm, Shropshire.

FIG. 10. BB 35415a. Internal mould of a pedicle valve, $\times 4$.

Whittery Shales, River Camlad, Shropshire.

FIG. 11. BB 35451a. Internal mould of a pedicle valve, $\times 2.5$.

Eocramatia dissimulata gen. et sp. nov. (p. 129)

Hope Shales, Brithdir Farm, Shropshire.

FIGS. 14, 9. Holotype, BB 35488a. Latex cast and mould of the interior of a pedicle valve, $\times 3.5$.

FIGS. 12, 15. Paratype, BB 35490a. Latex cast and mould of the interior of a pedicle valve, $\times 3.5$, $\times 5.5$.

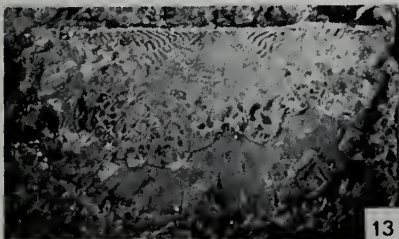
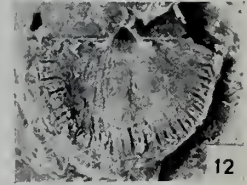
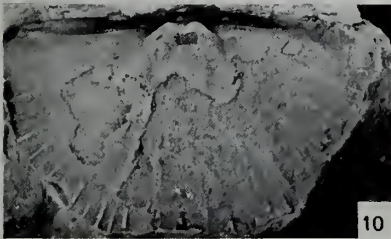
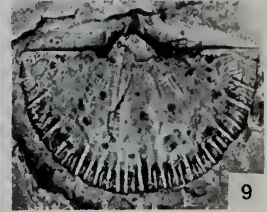
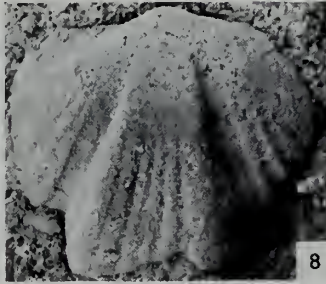
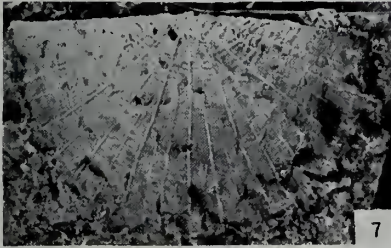
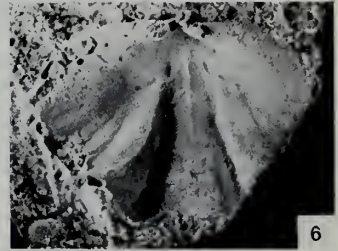
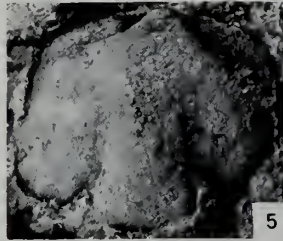
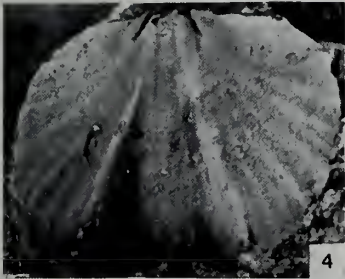
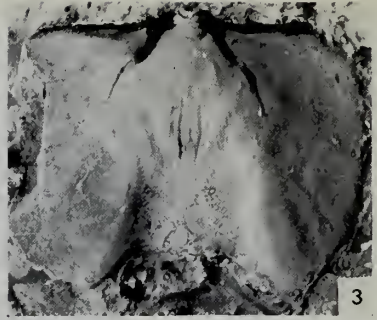
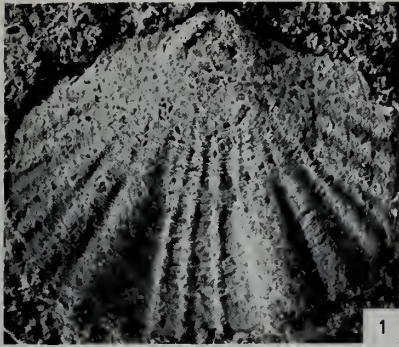


PLATE 22

Eocramatia dissimulata gen. et sp. nov. (p. 129)

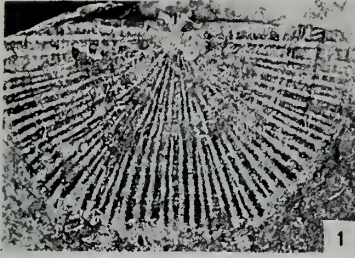
Hope Shales, Brithdir Farm, Shropshire.

- FIGS. 1, 2. Paratype, BB 35489a, b. Latex casts of the exterior and interior of a brachial valve, $\times 5.8$.
FIG. 3. Paratype, BB 35492. Latex cast of the exterior of a brachial valve, $\times 3.4$.
FIG. 5. Holotype, BB 35488b. Latex cast of the exterior of a pedicle valve, $\times 5.3$.
FIG. 6. Paratype, BB 35491a. Internal mould of a brachial valve, $\times 8$.

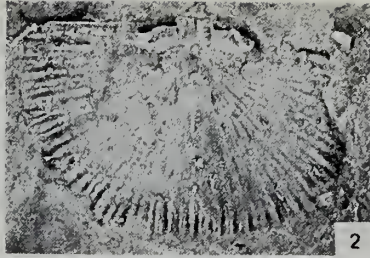
Sowerbyella antiqua Jones (p. 130)

Ffairfach Group, near Llangadog, Carmarthenshire.

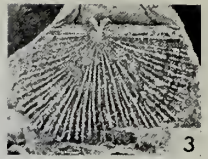
- FIGS. 7, 4. BB 35525. Latex cast and mould of the interior of a brachial valve, $\times 11.2$, $\times 7.1$.
FIG. 8. BB 35524. Latex cast of the exterior of a brachial valve, $\times 6.2$.
FIG. 9. BB 35530. Latex cast of the interior of a brachial valve, $\times 4.7$.
FIG. 10. BB 35529. Latex cast of the interior of a brachial valve, $\times 8.7$.
FIG. 11. BB 35526. Latex cast of the exterior of a brachial valve, $\times 5.5$.
FIG. 12. BB 35532. Latex cast of the interior of a brachial valve, $\times 6$.
FIG. 13. BB 35528. Latex cast of the exterior of a pedicle valve, $\times 5.5$.
FIG. 14. BB 35533. Internal mould of a pedicle valve, $\times 6$.



1



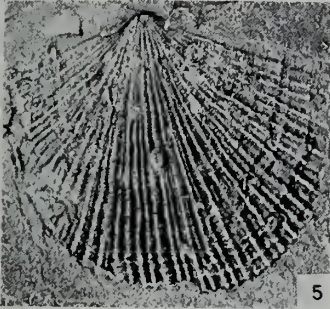
2



3



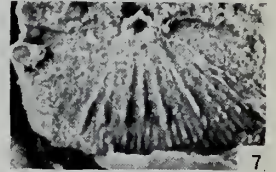
4



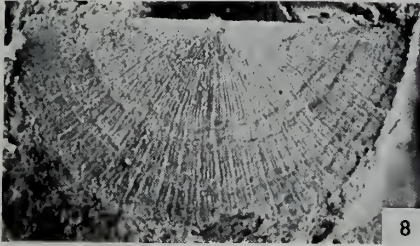
5



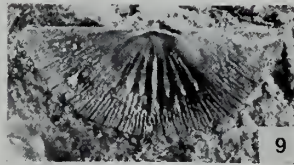
6



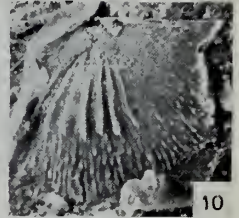
7



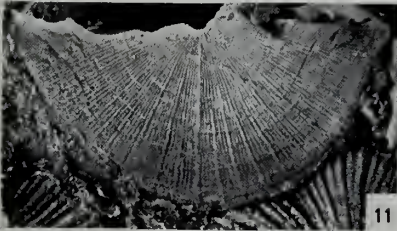
8



9



10



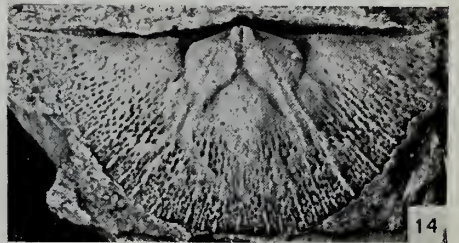
11



12



13



14

PLATE 23

Sowerbyella antiqua Jones (p. 130)

Ffairfach Group, near Llangadog, Carmarthenshire.

- FIG. 1. BB 35527. Internal mould of a pedicle valve, $\times 4.7$.
FIG. 3. BB 35531. Internal mould of a pedicle valve, $\times 6$.
FIG. 4. BB 35534. Latex cast of the interior of a brachial valve, $\times 6.5$.

Sowerbyella cf. antiqua Jones (p. 131)

Meadowtown Beds, near Meadowtown, Shropshire.

- FIG. 2. BB 35541a. Latex cast of the interior of a brachial valve, $\times 6$.
FIG. 5. BB 35536. Latex cast of the exterior of a brachial valve, $\times 8.7$.
FIG. 6. BB 35539. Internal mould of a pedicle valve, $\times 6$.
FIG. 7. BB 35540. Internal mould of a pedicle valve, $\times 5.8$.
FIGS. 8, 9. BB 35537a, b. Internal mould and latex cast of the exterior of a pedicle valve, $\times 7.3$, $\times 7.9$.
FIGS. 12, 10. BB 35542. Latex cast and mould of the interior of a brachial valve, $\times 8$.
FIG. 11. BB 35535. Latex cast of the exterior of a brachial valve, $\times 6$.
FIG. 13. BB 35538. Internal mould of a brachial valve, $\times 7$.

Sowerbyella multiseptata sp. nov. (p. 132)

Spy Wood Grit, near Rorrington, Shropshire.

- FIG. 14. Paratype, BB 35548b. Latex cast of the exterior of a pedicle valve, $\times 4.5$.
FIGS. 16, 15. Holotype, BB 35544. Latex cast and mould of the interior of a brachial valve, $\times 6.2$.
FIG. 17. Paratype, BB 35547a. Latex cast of the interior of a brachial valve, $\times 6$.
FIG. 18. Paratype, BB 35546a. Internal mould of a pedicle valve, $\times 7$.
FIG. 19. Paratype, BB 35545b. Latex cast of the exterior of a pedicle valve, $\times 10$.

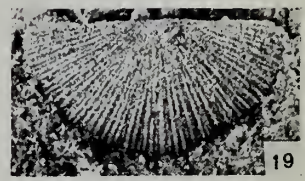
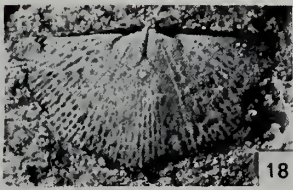
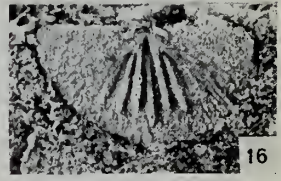
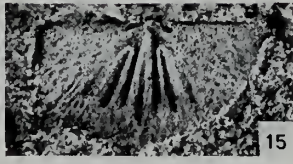
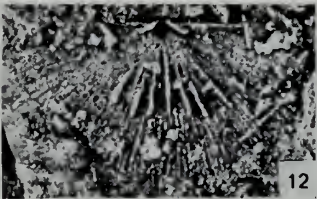
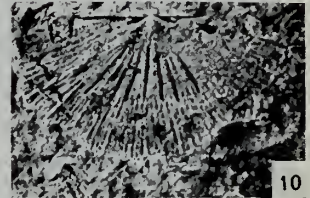
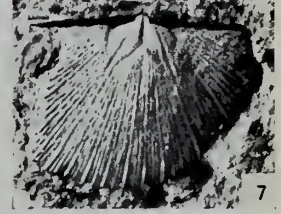
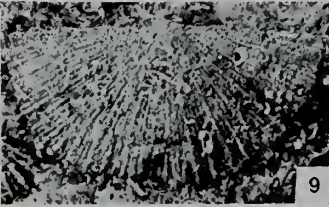
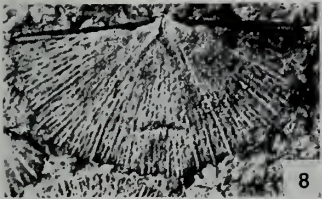
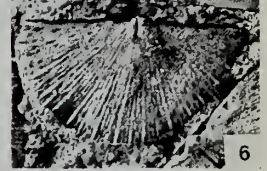
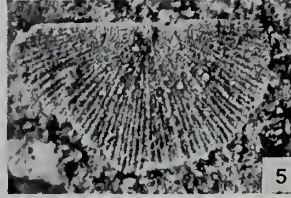
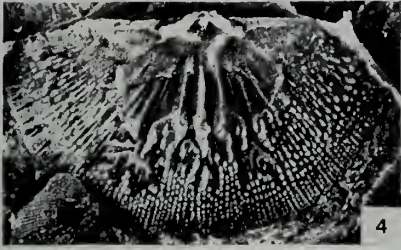


PLATE 24

Sowerbyella multiseptata sp. nov. (p. 132)

Spy Wood Grit, near Rorrington, Shropshire.

FIG. 1. Paratype, BB 35548a. Internal mould of a pedicle valve, $\times 6.6$.

FIG. 3. Paratype, BB 35545a. Internal mould of a pedicle valve, $\times 5.8$.

Sowerbyella cf. *sericea permixta* Williams (p. 133)

Aldress Shales, Ox Wood Dingle, Shropshire.

FIGS. 2, 10. BB 35552a, b. Latex casts of the exterior and interior of a brachial valve, $\times 6.8$.

FIG. 4. BB 35554b. Latex cast of the exterior of a brachial valve, $\times 5.1$.

FIGS. 6, 5. BB 35553a, b. Latex casts of the exterior and interior of a brachial valve, $\times 4.8$, $\times 5.7$.

FIG. 7. BB 35551a. Internal mould of a pedicle valve, $\times 3.7$.

Sowerbyella cf. *sericea* (J. de C. Sowerby) (p. 134)

Whittery Shales, near Marrington Farm, Shropshire.

FIG. 11. BB 35555. Internal mould of a pedicle valve, $\times 3.2$.

Whittery Shales, Whittery Wood, Chirbury, Shropshire.

FIGS. 14, 13. BB 35556a, b. Latex casts of the exterior and interior of a brachial valve, $\times 3.5$.

Whittery Shales, near Hockleton Bridge, Shropshire.

FIG. 16. BB 35557. Exterior of the pedicle valve, $\times 2.7$.

Sericoidea cf. *abdita* Williams (p. 139)

Hagley Shales, Church Stoke, Shropshire.

FIG. 8. BB 35485. Latex cast of the interior of a brachial valve, $\times 7.7$.

FIGS. 15, 12, 9. BB 35484a, b. Latex casts of the exterior and interior and the internal mould of a brachial valve, $\times 8$.

FIGS. 18, 17. BB 35487a, b. Latex cast of the exterior and the internal mould of a pedicle valve, $\times 8.6$.

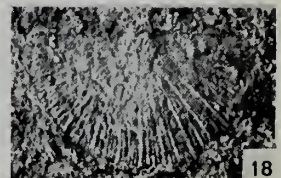
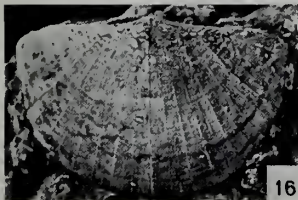
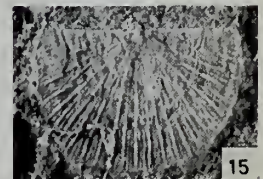
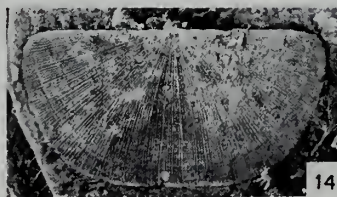
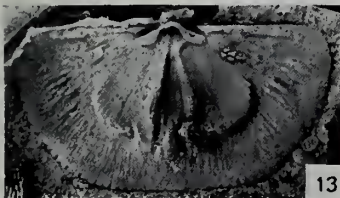
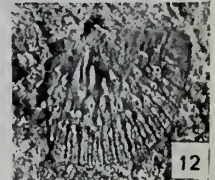
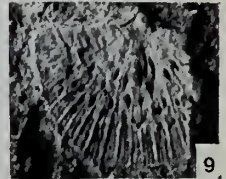
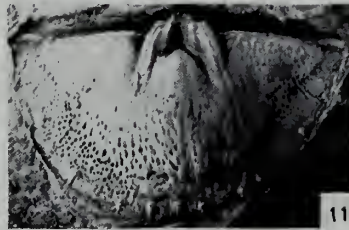
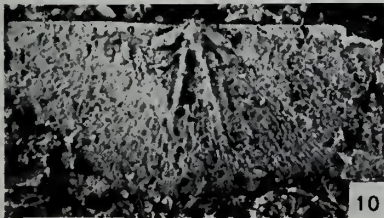
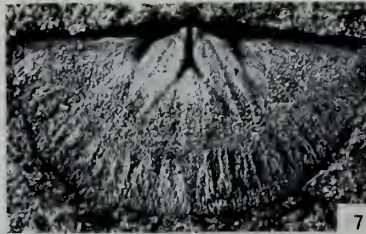
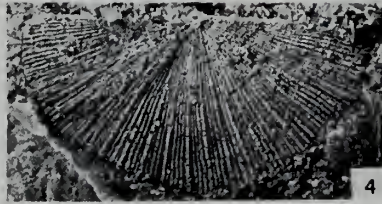
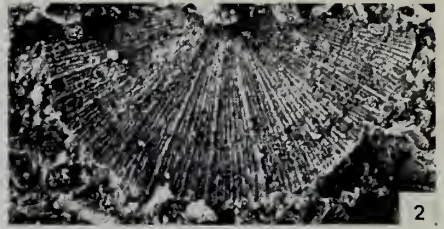


PLATE 25

Rafinesquina sp. (p. 143)

Whittery Shales, Whittery Quarry, Shropshire.

FIG. 1. BB 35496a. Latex cast of the interior of a brachial valve, $\times 3$.

Murinella sp. (p. 141)

Meadowtown Beds, Little Weston, Shropshire.

FIGS. 2, 3. BB 35421a, b. Latex cast of the exterior and the internal mould of a pedicle valve, $\times 5$, $\times 4\cdot6$.

Furcitella sp. (p. 140)

Whittery Shales, Whittery Quarry, Shropshire.

FIGS. 4, 5. BB 35422a, b. Latex cast of the exterior and the internal mould of a brachial valve, $\times 4$.

Rafinesquina delicata sp. nov. (p. 141)

Meadowtown Beds, Quinton's Quarry, Shropshire.

FIG. 6. Paratype, BB 35562. Latex cast of the interior of a brachial valve, $\times 2$.

FIGS. 8, 7. Paratype, BB 35559a. Latex cast and mould of the interior of a pedicle valve, $\times 2\cdot6$.

FIG. 9. Paratype, BB 35560b. Latex cast of the exterior of a pedicle valve, $\times 2\cdot9$.

FIG. 10. Paratype, BB 35561a. Internal mould of a pedicle valve, $\times 2\cdot9$.

FIG. 12. Paratype, BB 35563a. Latex cast of the interior of a brachial valve, $\times 3\cdot8$.

Meadowtown Beds, near Minicop Farm, Shropshire.

FIG. 11. Holotype, BB 35558a. Internal mould of a brachial valve, $\times 2\cdot9$.

FIG. 13. Paratype, BB 35564b. Latex cast of the exterior of a brachial valve, $\times 5\cdot4$.

Bystromena perplexa gen. et sp. nov. (p. 146)

Spy Wood Grit, near Middleton Church, Shropshire.

FIG. 14. BB 35366a. Latex cast of the interior of a pedicle valve, $\times 5\cdot6$.

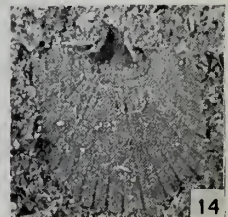
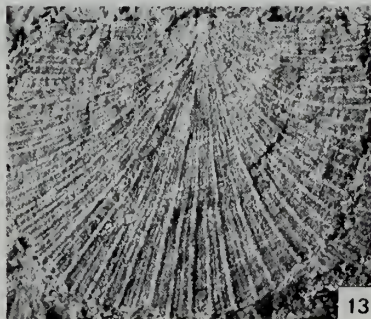
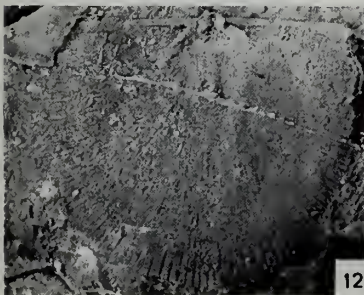
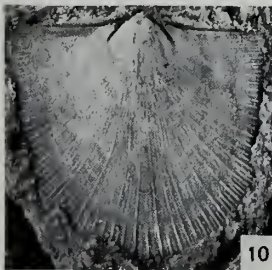
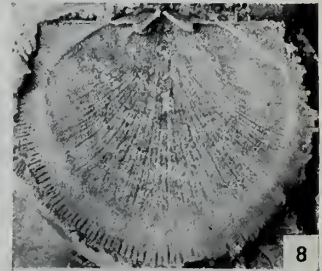
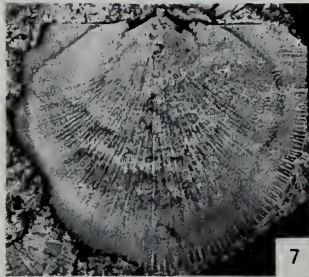
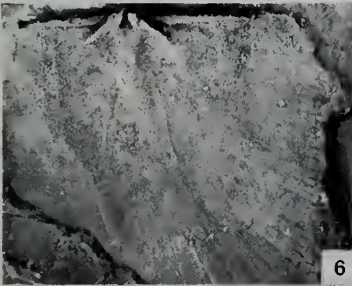
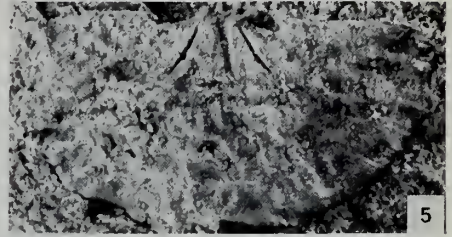
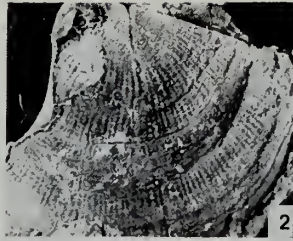
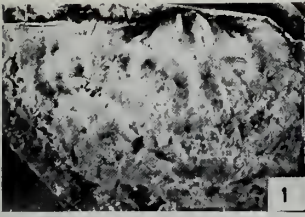


PLATE 26

Rafinesquina sp. (p. 143)

Whittery Shales, Whittery Quarry, Shropshire.

FIG. 1. BB 35496b. Latex cast of the exterior of a brachial valve, $\times 5$.

Kjaerina (Hedstroemina) sp. (p. 145)

Spy Wood Grit, near Rorrington, Shropshire.

FIG. 2. BB 35452. Internal mould of a pedicle valve, $\times 1.8$.

Bystromena perplexa gen. et sp. nov. (p. 146)

Spy Wood Grit, near Rorrington, Shropshire.

FIGS. 4, 3. Holotype, BB 35363. Latex cast and mould of the interior of a pedicle valve, $\times 3.4$, $\times 4$.

FIGS. 14, 9. Paratype, BB 35365a. Latex cast and mould of the interior of a pedicle valve, $\times 4.5$.

FIGS. 10, 5. Paratype, BB 35364a. Latex cast and mould of the interior of a pedicle valve, $\times 6.6$, $\times 4.3$.

FIGS. 6, 7. Paratype, BB 35370. Latex cast and mould of the interior of a brachial valve, $\times 7$, $\times 5$.

Spy Wood Grit, Spy Wood Brook, Shropshire.

FIGS. 12, 13. Paratype, BB 35368a. Latex cast and mould of the interior of a brachial valve, $\times 6$.

Spy Wood Grit, near Middleton Church, Shropshire.

FIG. 8. Paratype, BB 35367a. Latex cast of the interior of a brachial valve, $\times 6$.

FIG. 11. Paratype, BB 35366a. Internal mould of a pedicle valve, $\times 7.3$.

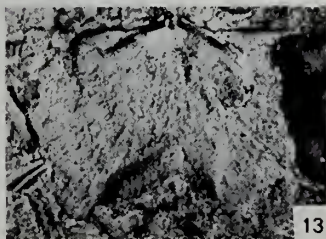
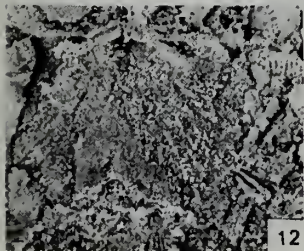
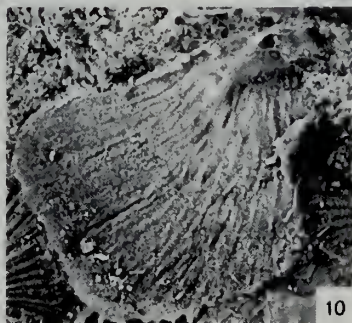
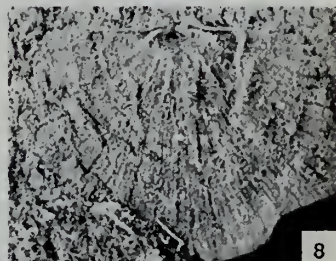
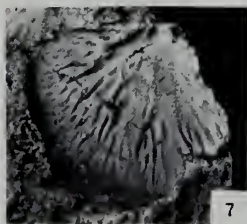
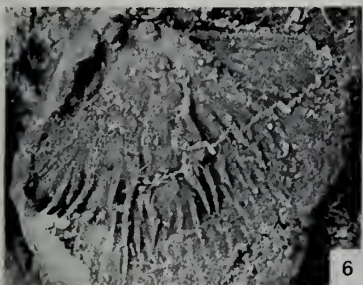
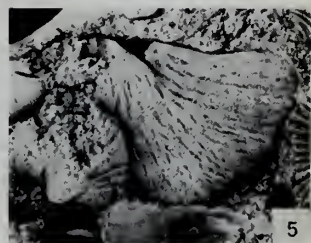
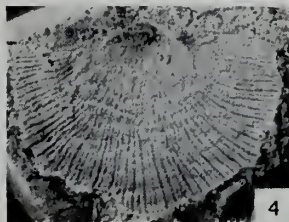
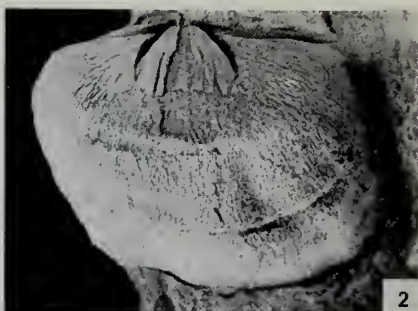


PLATE 27

Bystromena perplexa gen. et sp. nov. (p. 146)

Spy Wood Grit, near Middleton Church, Shropshire.

FIGS. 2, 1. Paratype, BB 35367a, b. Latex cast of the exterior and the internal mould of a brachial valve, $\times 7.5$.

Rostricellula sparsa Williams (p. 153)

Spy Wood Grit, near Rorrington, Shropshire.

FIGS. 3, 7. BB 35584a, b. Latex cast of part of the exterior and the internal mould of a brachial valve, $\times 6.9$, $\times 10$.

FIG. 4. BB 35585a. Internal mould of a pedicle valve, $\times 7.5$.

Leptaena cf. *ventricosa* Williams (p. 148)

Whittery Shales, near Hockleton Bridge, Shropshire.

FIG. 5. BB 35454. Internal mould of pedicle valve, $\times 2.5$.

Whittery Shales, near Marrington Farm, Shropshire.

FIGS. 8, 9. BB 35453a, b. External mould and latex cast of the interior of a brachial valve, $\times 4$, $\times 3.4$.

Kiaeromena cf. *kjerulfi* (Holtedahl) (p. 149)

Hagley Volcanics, near Church Stoke Hall, Shropshire.

FIG. 6. BB 37132a. Latex cast of the interior of a brachial valve, $\times 4.8$.

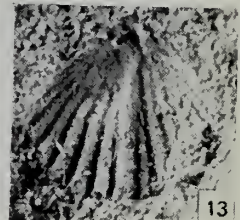
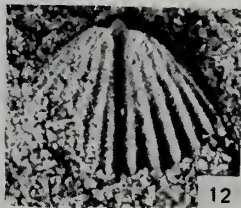
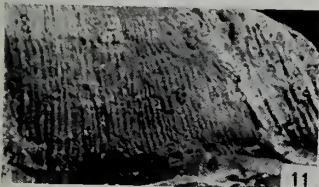
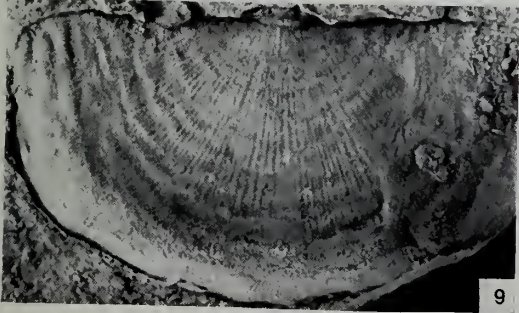
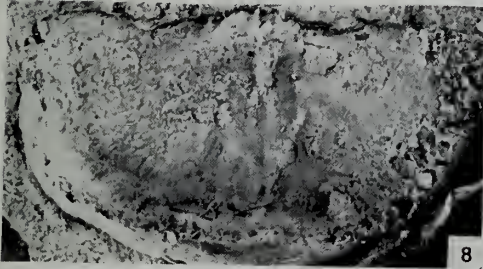
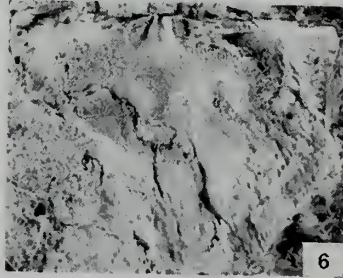
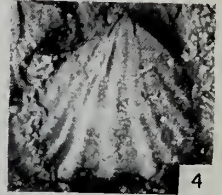
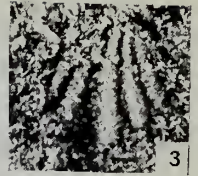
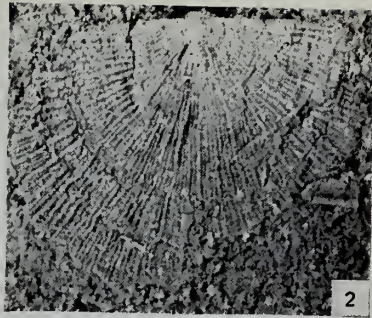
Whittery Shales, River Camlad, Shropshire.

FIGS. 11, 10. BB 35406a, b. Latex cast of the ornament and the internal mould of a pedicle valve, $\times 6$, $\times 2$.

Zygospira sp. (p. 154)

Spy Wood Grit, near Rorrington, Shropshire.

FIGS. 13, 12. BB 37133. Latex cast and mould of the interior of a brachial valve, $\times 11$.



Euorthisina* cf. *moesta minor Havlíček (p. 150)

Mytton Flags, near St Luke's Church, Shropshire.

- FIG. 1. BB 35377a. Moulds of a group of shells in an orthocone, $\times 5$.
 FIG. 5. BB 35377b. Latex cast of the exterior of a brachial valve in the orthocone, $\times 6$.
 FIG. 2. BB 35378a. Internal mould of a pedicle valve, $\times 4.4$.
 Mytton Flags, near Wood House, Shropshire.
 FIG. 3. BB 35379a. Internal mould of a pedicle valve, $\times 6.3$.
 FIG. 8. BB 35380a. Internal mould of a brachial valve, $\times 4$.

Euorthisina moesta (Barrande) (p. 150)

Šárka Formation (Llanvirn), Rokycany, Czechoslovakia.

- FIG. 4. BB 37160. Dorsal view of the internal mould of a shell, $\times 1.8$.
 FIG. 6. BB 37161. Internal mould of a pedicle valve, $\times 2.4$.
 FIG. 7. BB 37162. Internal mould of a brachial valve, $\times 2.5$.

Parastrophinella musculosa sp. nov. (p. 151)

Spy Wood Grit, near Rorrington, Shropshire.

- FIGS. 9, 17. Holotype, BB 35598a, b. Latex cast of the exterior and the internal mould of a pedicle valve, $\times 5$, $\times 4$.
 FIG. 10. Paratype, BB 37108. Internal mould of a brachial valve, $\times 3.7$.
 FIG. 11. Paratype, BB 37107. Internal mould of a pedicle valve, $\times 5.5$.
 FIG. 12. Paratype, BB 35599a. Internal mould of a brachial valve, $\times 5$.
 FIG. 13. Paratype, BB 35600. Internal mould of a brachial valve, $\times 4.5$.

Parastrophinella sp. (p. 152)

Hagley Volcanics, near Church Stoke Hall, Shropshire.

- FIGS. 14, 15. BB 35461a, b. Latex cast of the exterior and the internal mould of a pedicle valve, $\times 1.8$.

Sericoidea* cf. *abdita Williams (p. 139)

Hagley Shales, near Church Stoke, Shropshire.

- FIG. 16. BB 35486b. Internal mould of a brachial valve, $\times 11.5$.

